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H. A. Gossard.

REPORT

OF

THE ENTOMOLOGIST,

CHARLES V. RILEY, M. A., PH. D.,

FOR

THE YEAR 1886.

WITH ILLUSTRATIONS.

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REPORT OF THE ENTOMOLOGIST.

INTRODUCTION.

SIR: I have the honor to present herewith my annual report for the year 1886. It is confined to the consideration of a few prominent and important insects that have not before been fully treated of in Department publications, and I have omitted from it, because of the limitation as to number of pages allotted to the Entomologist, many briefer notes and articles that have been prepared as the result of the year's work. These omitted portions will at once be prepared for special bulletins.

The fruit interests of the Pacific coast have of late years been more and more threatened by injurious insects, and in the present report the leading place is given to the consideration of the Cottony Cushion-scale (*Icerya purchasi*), which is perhaps the greatest pest that the fruit-growers in that section have to contend with. I was urged last spring by many prominent horticulturists and by Hon. W. W. Morrow, M. C. from the fourth district of California, to personally visit the infested region, but as this was impossible then on account of impaired health and important duties in the East, Messrs. D. W. Coquillett and Albert Koebele were sent to Los Angeles early in the year, with instructions to carry on through the summer an extensive series of experiments and observations upon the species. It will be seen from the context that this is one of those insects which have, naturally, extremely limited powers of spreading, and that its introduction from one continent to another and its subsequent spread might easily have been prevented had vigilance and intelligent appreciation of the dangers of such an introduction prevailed in years gone by as they are beginning to prevail now. The article is supplemented by detailed reports on experiments by Messrs. Coquillett and Koebele, which indicate the difficulties of controlling the pest, but at the same time show that these difficulties may be overcome.

The kerosene emulsions, in different proportions, which have proved so entirely satisfactory against the scale-insects of the Orange in Florida, have in general failed to win the good opinion of orange-growers in California. Mr. Matthew Cooke and other writers in the latter State have pronounced the kerosene emulsions inferior to caustic soda and caustic potash, and even to strong solutions of whale-oil soap.

Until this year I have been unable to offset the decision of these gentlemen with the result of careful experiment, though I have always believed their want of success was due to imperfect preparation of the emulsions or imperfect application of them. I was also inclined to give some credence to the theory advanced by Prof. E. W. Hilgard, that the dryness of the atmosphere in California induced a more rapid evaporation of the kerosene in the emulsion, which accounted for its inferior results. Moreover, the Cottony Cushion-scale is much less susceptible to the action of insecticides than any Floridian species on account of the protection afforded by the large waxy mass which it secretes, as well as on account of its great vitality.

The detailed reports on remedies just referred to show that kerosene emulsions must still be placed at the head of the list, not only for ordinary scale-insects, but for this *Icerya*, so far as efficacy is concerned, though other remedies have the advantage of being cheaper. In the proportion of 1 part of the soap emulsion to 15 parts of water it proves a perfect remedy for their Red Scale (*Aspidiotus aurantii*), a species which has done incalculable damage in Australia and has created much alarm in California. After a thorough application of the mixture in March Mr. Coquillett found that every scale-insect was killed, and at the expiration of two months all had dropped from the leaves. Used in the same proportion on the Cottony Cushion-scale, however, it does not kill the old females with the egg-masses, nor all of the eggs. Used at twice this strength it kills all of the eggs, as well as the old females, and even when properly used at the rate of 1 part of the emulsion to 5 parts of water it leaves the tree uninjured.

Mr. Coquillett reports, with reference to the much-praised caustic soda, that it has no effect on the eggs of the *Icerya*, even when applied so strong as to burn the bark brown and kill all the leaves. Similarly, whale-oil soap, one pound to two gallons of water, does not kill the eggs directly, nor does hard soap and water in the same proportions, although the effect of the latter seems greater than that of the former. They both, however, harden the egg-masses so that a large proportion of the young larvæ are unable to escape. The experiments add greatly to the value of ordinary tobacco, for one of the most effectual washes used is made by boiling one pound of tobacco leaves in one gallon of water until the strength has been extracted from the leaves, and then adding enough water to make two gallons. This wash, however, costs about 5 cents per gallon, and is too expensive for ordinary use. Mr. Koebele, experimenting through August, September, and October, found that kerosene emulsified with soft-soap penetrates the egg-sacs well, kills the old scales, and leaves the tree uninjured. Emulsions of crude petroleum, although much cheaper, he found very apt to injure the trees. He devoted his chief attention, on account of their great cheapness, to the preparation of soaps and resin compounds. He succeeded in making a number of these mixtures, which, when properly diluted, need not cost more than from one-third to one-half of a cent per gallon, and which, if thoroughly applied, will bring about very satisfactory results, killing the insects and either penetrating or hardening the egg-masses so as to prevent the hatching of the young. I am strongly of the opinion that the value of the soap washes depends somewhat on the season of their application, and that the greater success of Mr. Koebele with them as compared with that of Mr. Coquillett was probably due to the fact that his experiments were made during the dry or rainless season.

In connection with the subject of kerosene emulsions, I may put on record here an important discovery made last spring in carrying on further experiments at the office in emulsifying this oil. It is that the white of eggs with a little sugar may be used as a satisfactory substitute for milk where this is not accessible.

If the white of 2 eggs, about 3 tablespoonfuls of sugar, $\frac{3}{4}$ quart of water, and $1\frac{1}{4}$ quarts of kerosene are worked through a force-pump and cyclone-nozzle for from 5 to 10 minutes a cream-like emulsion is produced, which can be diluted with water to any desired amount without any separation of the oil; provided that the emulsion is not allowed to stand for any length of time.

Another investigation that has occupied considerable of my time

lately is that in reference to the Southern Buffalo Gnats. The loss occasioned by the attacks of these upon domestic animals has been of late years very great, and the Division has been strongly appealed to by influential stock-raisers in the lower Mississippi Valley for information. Messrs. F. M. Webster, Otto Lugger, and Francis Fillion have each been directed to make special investigations and experiments during the year in different parts of the South, and Dr. Warren King, of Vicksburg, has aided in various ways. At the time when these investigations began the particular species concerned had not been determined; nor was anything known of their habits in the early stages. These habits were surmised from what was known of other species of the genus both in this country and Europe, which, as a rule, breed in clear, rapid, and rocky streams; but it was a question how our Southern species could breed so numerously in the lower alluvial Mississippi country.

It results from the investigation that there are more particularly concerned two species, which may be known and distinguished as the Southern Buffalo Gnat (the larger and more common of the species) and the Turkey Gnat, the names by which they are very generally known in the country affected. They are both undescribed species, and I have given them the names of *Simulium pecuarum* and *S. meridionale* respectively. The habits of both species are similar, and both have been found to breed in the more swiftly running currents of bayous and larger streams which are permanent and do not dry up in midsummer. The larvæ are found attached to the masses of drift-wood and leaves which form at points, and which, by impediment, induce a more rapid current on the surface. Very full details will be found in the article, and at its close I have discussed the bearing which seasons of overflow may possibly have on the increase of these insects. Much yet remains to be ascertained, however, especially as to oviposition, the eggs, and the early habits of the larvæ.

Another insect that will be found fully treated of is the common Fall Web-worm (*Hyphantria cunea*), which abounded during the past year in the Eastern States in a phenomenal way, and which was so destructive to the shade trees of the Capital as to attract an unusual share of attention and to call forth many requests for information. Many facts hitherto unpublished, both as to its habits and natural enemies, will be found recorded, while advantage has been taken of the very favorable opportunity afforded by the exceptional increase of the species in Washington City to carefully study its relative preference for different trees. I have already published in my report for the year 1883, and in Bulletin 6 of this Division, in considering the Imported Elm Leaf-beetle, full directions for protecting trees from leaf-devouring insects, and as it is inadvisable to repeat what is already accessible in published form, I have given but a brief summary of the means available for protecting trees from this Fall Web-worm. Moreover, the spraying appliances that are most useful against the scale-insects, and treated of in considering the Cottony Cushion-scale of California, are equally applicable here, and in so far as they differ from those already described and published in previous reports they will be found treated of in connection with said scale. So far as the city of Washington is concerned (and the same will apply to all cities) there can be little doubt that the great increase of this Fall Web-worm of late years has been largely due to two circumstances: First, the prevalence of the English Sparrow and its indisposition or inability to feed upon this worm, while making

more room for it by destroying other less injurious and smooth species; secondly, the use of the wooden tree-boxes, which afford such excellent winter shelter for the cocoons.

Some recent experience is recorded with regard to Joint Worms, and the interesting fact is brought out that alternation of generation occurs among them, and that in the genus *Isosoma*, to which they belong, two forms, which have hitherto been considered good species, are in reality seasonal dimorphic forms of one and the same species, as I have always suspected would prove to be the case.

The year 1886 may be said, entomologically, to have been an ordinary one, and notwithstanding the exceptional injury by some, there has been, perhaps, less damage than usual from injurious species.

Among these last must be mentioned the Hop Aphis (*Phorodon humuli*), which was so destructive in the great hop regions of New York State as to have caused an almost total loss. The best evidence I have been able to obtain from correspondents is that in a great many cases no harvest was made, and on an average only about 10 per cent. was harvested. In this connection I have taken steps to carry on a series of practical experiments the coming year, and I may state as a matter of interest that, from investigations made last September in the hop fields I am led to believe that I have discovered the winter egg of this hop-louse upon plum trees, so that its mode of hibernation, which has hitherto been a mystery, has thus been settled. Full verification of this fact, however, cannot be obtained without another season's observation, and for this reason I have been unwilling so far to publish anything in detail.

In my last report I showed that, so far as experiments in silk-culture are concerned, no decisive results could well be hoped for until the Serrell automatic reel could be tested at some point in Washington where the details could be well controlled and observations made by myself and assistants, and where the work could be carried on for at least two years. Congress therefore appropriated $10,000 for this particular purpose, and the reeling stations at San Francisco, New Orleans, and Philadelphia have been abandoned. The brief report of the work in this direction, which will be found in the following pages, must be looked upon as preliminary; for, while the figures given look somewhat discouraging, no fair and proper estimate can be made before another year. The confirmation which our reeling has so far given of the value of the Osage Orange as silk-worm food is interesting, and entirely in keeping with what I expected and what I have previously recorded.

Work has been continued at the apicultural station at Aurora, Ill., as far as the means would permit, and a report on some of the experiments by Nelson W. McLain, in charge of the station, is embodied, while some further reports will be included in a special bulletin. I have endeavored by occasional consultations with Mr. McLain to keep the experiments in lines that have been more or less neglected by bee-keepers and in which there was hope of valuable results. The most important of these are in the direction of controlling fertilization. Most of the improvement in bee-culture in the past has been in the direction of mechanical appliances, while these experiments have in mind the improvement of the bee itself, so as to increase its honey-yielding power, and thus advance the interest in the same way that the dairy interest has been advanced by improving the milk and butter producing qualities of the cow.

A year ago Congress added $5,000 to the appropriation of the Divis-

ion for the promotion of economic ornithology, and charged the Entomologist with carrying on the work. This appropriation was made at the instance of Professor Baird, myself, and Dr. C. Hart Merriam, and in obedience to a memorial from the American Ornithologists' Union. Work was begun by your appointing Dr. Merriam as a special agent in charge, and Dr. A. K. Fisher and a clerk to assist. The scope of the work planned was indicated in my last annual report, it being arranged that the part relating to food habits should be dealt with by myself and former associates because of its entomological bearing; while to Dr. Merriam was assigned all the other phases of the work, he being particularly interested in the migrations of birds as chairman of the committee on migrations of the Union above mentioned.

Early in July, 1885, a circular was prepared (Circular 20, Division of Entomology) setting forth the objects of the investigation, and asking information concerning the food-habits of certain well-known birds which were supposed to be beneficial or injurious to the farmer. About 2,000 copies of this circular were distributed to farmers and ornithologists throughout the country, and a large number of replies were received. During the winter two additional circulars (Circulars 24 and 27, Division of Entomology), accompanied by three schedules, were prepared, which related to the migration and geographical distribution of North American birds. These were sent to the keepers of light-houses along the coasts and lakes and to the regular observers of the American Ornithologists' Union.

Special attention was given during the year to the English Sparrow question, and a large amount of information has been collected. The ravages of birds in the rice fields of the South was another matter which early received attention, and Dr. Fisher was sent on an extended tour through the rice-growing districts, giving particular attention to those of Georgia and Louisiana. The formation of a collection of the stomachs, crops, and gizzards of birds was early undertaken, and has been continued to the present time.

From the outset I have recognized that while the ornithological work, so far as it related to food-habits, was legitimately placed in the Entomological Division, because of its intimate connection with the subject of entomology, yet there were many other lines of inquiry that have no particular bearing on entomology, and could not well be prosecuted in earnest without detracting from the time which should be devoted to the more legitimate sphere of the Division. As soon, therefore, as it was ascertained that there was some prospect of getting a new Division created I strongly urged such action, and a new Division of Ornithology and Mammalogy was created last June by Senate amendment to the House bill, it having been previously arranged that the Entomologist should take charge of the question of food-habits so far as they relate to insects. Unfortunately, however, the appropriation to the new Division was taken from the Entomological Division, thus reducing the means of this last below what it was two years ago, so that the work has been correspondingly crippled by the stoppage of investigations already begun (especially in California and the South), by the discharge of some of the employés and the reduction in salary of some of the others.

So much of the time devoted to ornithology during the year having been taken up in original investigations and the accumulation of material, Dr. Merriam has submitted no formal report, and the results

of the investigations, so far as they have been written up, will be published directly under the new Division.

In this connection, as evidence of the interest abroad in applied entomology, I would refer to the holding of an international exhibition of machinery and contrivances for applied remedies against fungi and insects that are destructive to cultivated plants. This congress was held in October at Florence, and his Excellency, B. Grimaldi, the minister of agriculture, industry, and commerce for Italy, was very anxious to have the Division represented by such discoveries and mechanical appliances as have been developed in its work of late years. He was also very anxious to have a representative from the Department to take part in the discussions of the congress to be held in connection with the exhibition. The Entomologist was in fact made one of the jurors, and it is to be regretted that, by the terms of our appropriation, the Department was unable to have entomological representation at said congress. From reports of the congress that have come to hand, kindly furnished by Prof. Gustav Foëx, in charge of the experimental school of agriculture at Montpellier, and of Henri Grosjean, of Paris, it is evident that they have made good use of the remedies and contrivances published and recorded in our annual reports, and that, with the exception of experience against the Grape-vine Phylloxera, there was not very much that would have interested us in America.

The work of the Division is best represented by its published results, as, after all, its value is proportioned to the manner in which it is placed upon record and made available to the public, though there is of necessity a great amount of work that is not accounted for in print. In the matter of published and contemplated reports and bulletins, the following list represents the activity of the Division fairly well:

The publications of the present year have been as follows:

Bulletin No. 8. The Periodical Cicada. An account of Cicada septendecim and its tredecim race, with a chronology of all broods known. pp. 46.

Bulletin No. 11. Reports of Experiments with Various Insecticide Substances, chiefly upon insects affecting garden crops. pp. 34.

Bulletin No. 8. Second edition.

Insects affecting the Orange. Report by H. G. Hubbard on the insects affecting the culture of the Orange and other plants of the Citrus family, with practical suggestions for their control or extermination. pp. 227; figs., 95; plates, 14.

Fourth Report of the United States Entomological Commission, by C. V. Riley, being a revised edition of Bulletin No. 3, and the final report on the Cotton Worm, together with a chapter on the Boll Worm. pp. 546; figs., 45; plates, 64.

Report of the Entomologist for the year 1885. pp. 154; plates, 9.

Bulletin No. 12. Miscellaneous Notes on the Work of the Division of Entomology for the season of 1885. pp. 45; 1 plate.

Bulletin No. 9. The Mulberry Silk-worm; being a manual of instructions in silk-culture. Sixth revised edition of Special No. 11. pp. 62; figs., 29.

Those in course of preparation are:

Final Report on Insects injurious to Forest Trees (nearly completed).

Bibliography of Economic Entomology. A critical list of the economic writings of American entomologists.

Report on Insects affecting Domestic Animals.

Report on Remedies. A critical and classificatory treatise upon all the remedies which have been recommended against injurious insects.

Report on the Insects affecting Garden Crops of Florida.
Report on the Insects affecting the Grains.
Report on Insects affecting the Hop Crop.
Report on Insects affecting the Cranberry Crop.
Report upon the Grape-vine Phylloxera.
Monograph of the Acrididæ (destructive Grasshoppers).
Monograph of the Noctuidæ (Cut-worms, &c.).
Bulletin on Acronyctas (destructive tree-caterpillars).
Report on the Insectivorous Habits of Birds.
Several bulletins.

Dr. Packard has continued work on the Report on Forest Insects. He spent a portion of March and April in Northern and Central Florida studying and collecting the species injurious to Live and Water Oak, as well as to the Pines and Cypress. His observations go to corroborate those of others who have studied the Florida insect fauna, viz, that while a large proportion of the insects feeding on the oaks in Central Florida differ from those found in the Northern States, yet the pine insects from Maine to Florida belong to nearly one and the same fauna. During the summer months he worked in Maine, on the shores of Casco Bay, and a considerable amount of work was also done near Jackson, in New Hampshire, and around Providence. A report by him on some of the insects observed, and especially on a worm injurious to spruce buds, has been submitted, and will be published in the next bulletin.

Mr. F. M. Webster has continued investigations on the insects affecting our grains and forage plants, and his report, included herewith, contains a number of interesting observations, and also a list of 102 species of insects frequenting Buckwheat, with notes of their relative abundance and their method of attacking the plant.

Mr. Lawrence Bruner has continued work in Nebraska, and a special report from him will be published in bulletin form.

Prof. Herbert Osborn, of Ames, Iowa, has continued to assist me in work upon the insect parasites of domestic animals.

Miss M. E. Murtfeldt and Mr. J. G. Barlow were each engaged during the year for brief periods in various observations in Missouri, and Mr. William H. Ashmead similarly for a brief period in Florida.

Work by Mr. B. P. Mann on the Bibliography of Economic Entomology has been interrupted by the reduction in the appropriation, but otherwise the Divisional force at the Department remains the same, Messrs. E. A. Schwarz and Theo. Pergande assisting in the office work.

The illustrations to this report have been made by Miss Lillie Sullivan and Dr. George Marx, with the supervision of myself or of Mr. Howard.

I take pleasure, in conclusion, in acknowledging my indebtedness to Mr. Otto Lugger for assistance in the preparation of the article on the Buffalo Gnats and for the satisfactory manner in which he carried on his observations at Memphis, and particularly to Mr. L. O. Howard, who has had charge of the Division during my absence, and who has materially assisted me throughout both in the office correspondence and the preparation of reports. December 24, 1886.

Respectfully submitted,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

MISCELLANEOUS INSECTS.

THE COTTONY CUSHION-SCALE.

(*Icerya purchasi* Maskell.)

Order HEMIPTERA; family COCCIDÆ.

[Plates I, II, III, IV, and V.]

INTRODUCTORY.

We have, during the year, been conducting a special investigation of the habits of and remedies for the so-called Cottony Cushion-scale of California, an insect which for the last eight years has occupied much of the attention of the horticulturists of that State. We have been much interested in this pest since it was originally sent to us while in Missouri by Mr. R. H. Stretch from San Francisco in 1872, and have watched its increase and spread, until it became evident from its alarming prolificacy, from the great diversity of its food-plants, from its supposed immunity from the attacks of natural enemies, and from the protection against the action of insecticides afforded by its abundant waxy excretions, that especial study and experiment were much needed.

The following account of the insect is prepared from published accounts and unpublished correspondence; from our biologic notes made at the office in Washington, chiefly in 1878, 1880, and 1886; but more especially from our recent experience in the field (which the delay in publishing the report has enabled us to partly embody), and the observations of Messrs. Coquillett and Koebele, whose reports on experiments made to destroy it will be found given in full among the reports of agents.

GEOGRAPHICAL DISTRIBUTION.

So far as we have been able to learn, up to the date of present writing, the Cottony Cushion-scale is found only in California, in Australia, in South Africa, and in New Zealand. We shall discuss its introduction into California and its present limitations in that State in subsequent sections of this paper, and what we know of its spread in the other countries mentioned is here considered.

IN AUSTRALIA.—As will appear farther on, the evidence collected goes to prove that this insect is indigenous to Australia and has been exported from this colony to the two other colonies in which it occurs and to the United States. We have very few facts as to its occurrence in Australia and these are taken at second hand. We have addressed communications to a number of naturalists in different portions of that country, but their replies have at this writing not been received. From the "Report of the Commission appointed by his excellency the governor to inquire into and report upon the means of exterminating the insect of the family '*Coccidæ*,' commonly known as the 'Australian Bug,'" published at Cape Town, 1877, and from the letter of Mr. Roland Trimen, dated February 5, 1877, and published by the government secretary of Cape Colony as "Government Notice No. 113, 1877," we find that at that time specimens of the insect were sent from Cape Town to different portions of Australia, and that re-

plies were received as follows: The Queensland authorities simply promised inquiry and report. The government of South Australia did not recognize the insect in question as a native of that colony. The inquiry to Victoria was referred to Prof. Frederick McCoy, director of the National Museum at Melbourne, who identified the insect as a new *Dorthesia*, "common in Victoria on different kinds of *Acacia*."

This is the extent of our information. Mr. Maskell, in his second paper on this species (Transactions and Proceedings New Zealand Institute, XIV, p. 226, 1881), writes: "When in Australia a few months ago I observed at Ballarat an insect, certainly an *Icerya*, but I think not *I. purchasi;* but I had no opportunity of bringing away a single specimen." There exists, then, a possibility at least that the insect under consideration is found at Ballarat as well as around Melbourne.

IN CAPE COLONY.—We find in the "Report of the Commission," &c., just cited, the following information on the spread of the insect in this colony:

From the answers received it would seem that the insect, having first appeared and succeeded in establishing itself in Cape Town and the vicinity, gradually spread along the lines of traffic by land and sea to different parts of the colony; and we may mention, in evidence of its irregular dispersal by chance methods of conveyance, that it was observed in the village of Ookiep, Namaqualand, only a few months after its first discovery in the Cape Town Botanical Gardens in 1873, and yet was not seen in the neighboring division of Stellenbosch till the later end of 1876.

The limits to which the insect had extended at the time of the publication of the report of the commission (1877, presumably the latter part of the year) included the following localities: Cape Town and neighborhood, Simon's Town, Stellenbosch (Mulders Vlei), Malmesbury, Paarl, Wellington, Namaqualand (Ookiep), Bredasdorp, George (Brak River), Uitenhage, East London.

We have no information as to the present status of the insect in this colony, as the replies to our letters of inquiry have not yet come to hand.*

IN NEW ZEALAND.—From the paper containing Mr. Maskell's original description of *Icerya purchasi* (Trans. and Proc. N. Z. Inst., XI, 220, 1878), we learn that the insect was first noticed at Auckland. A note by Mr. E. A. MacKechnie (Ibid., XIV, 549, 1881) indicated that it had greatly increased in presumably the same neighborhood in 1881. In Mr. Maskell's second paper (Ibid., p. 226) he mentions in a foot-note that he had just received the insect from Napier. In his third paper (Ibid., XVI, 140, 1883) he writes as follows:

Icerya purchasi has spread greatly in the last two years. It had just reached Napier at the date of my last paper. It has now established itself in that district not only in gardens, but in the native forests. In Auckland it is attacking all sorts of plants. * * * It has reached Nelson, and I have had many communications from that place complaining of its ravages. * * * Whether this pest will spread in our colder southern climate (Christchurch) as it has in the warmer north remains to be seen. Our gardeners here are not in much dread of outdoor insects; they confine their attention to those in greenhouses. They may be right; still the winter even in Canterbury is not severe enough to kill these insects, and I know that in the Christchurch public gardens many trees have had to be burnt simply on account of the ravages of *Coccidæ*.

We have no information on this point from this colony later than 1883, but have taken steps to ascertain the present spread of the pest.

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*Just as the report is being sent to the printer we learn from Miss Ormerod that she has received specimens from Port Elizabeth, Cape Colony.

IMPORTATION OF THE SPECIES INTO CALIFORNIA.

The first printed record, with which we are acquainted, of the occurrence of the Cottony Cushion-scale in California is Mr. Stretch's article in the Proceedings of the California Academy of Sciences, Vol. IV, read September 16, 1872. In opening this paper he refers to the fact that "at a former meeting certain insects forwarded to this society from Menlo Park, San Mateo County, by Mr. Gordon," were referred to him for examination. A careful search through the previous proceedings fails to show any mention of this previous sending, though at the meeting of July 1, 1872, Mr. John Hewston, jr., "exhibited some limbs of Australian Acacia from San Mateo which were infested by a species of Coccus, and stated that the insect had not only been detected in its depredations upon said tree, but also upon the orange trees." This latter reference may very possibly have been to the Cottony Cushion-scale, and if so it is interesting, as indicating already a spread of some miles from Menlo Park.

All the slight evidence possessed points to the introduction of this scale on Australian Acacia by Mr. George Gordon about 1868 or 1869. Mr. Stretch says:

> This being all the information to be derived from the specimens referred to me, I visited Menlo Park in search of further information, and received a very hearty welcome from Mr. Gordon. The supposition is that the insect was imported from Australia some three years ago; at any rate it seemed to originate on the *Acacia latifolia.*

This was evidently Mr. Gordon's supposition, and the plain inference is that about three years previous to this time certain Acacias had been imported by Mr. Gordon from Australia as plants or cuttings contrary to the general custom, although it is not stated in so many words.

Dr. A. W. Saxe, of Santa Clara, Cal., in 1877, wrote:*

"So far as I can ascertain, it was brought to California on some plants imported from Australia by the late George Gordon, of Menlo Park (the sugar refiner)."

In the introduction to our annual report as Entomologist to this Department for 1878 we referred to the serious complaints that came from the Pacific coast of injury by it to orchard and ornamental trees, and from specimens received from Dr. Saxe (Mr. Maskell's papers being unknown here then) referred it to the genus *Dorthesia*, and remarked:

> It is an Australian insect, and has of late years been introduced on Australian plants into South Africa, where, as I learn from one of my correspondents, Mr. Roland Trimen, curator of the South African Museum, it has multiplied at a terrible rate, and become such a scourge as to attract the attention of the government. It has evidently been introduced (probably on the Blue Gum or *Eucalyptus*) to California, either direct from Australia or from South Africa, and will doubtless become quite a scourge; because most introduced insects are brought over without the natural enemies which keep them in check in their native country and consequently multiply at a prodigious rate. It will be naturally partial to Australian trees, and shows a preference for Acacia, Eucalyptus, Orange, Rose, Privet, and Spiræa.

Professor Comstock, in the Annual Report of the Department of Agriculture for 1880, p. 348, cited this article of Dr. Saxe's as the earliest article with which he was acquainted, and repeated Dr. Saxe's opinion as to the introduction of the insect.

Beyond this we are able to get no information upon the subject, and these data are in all probability the first connected with the introduction of the Cottony Cushion-scale. There may possibly have been

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* *California Agriculturist and Artisan*, December, 1877.

subsequent and independent importations, but that this is the one from which the main spread originated there can be little doubt.

ITS SPREAD AND PRESENT LIMITATION IN CALIFORNIA.

We are indebted to Mr. Matthew Cooke, of Sacramento, for communicating a lengthy and careful account of the localities in which the pest at present exists in California. Mr. Cooke has mapped out ten districts, six in the counties of Marin, San Mateo, Santa Clara, Sacramento, Sonoma, and Napa, in the San Francisco region, and four in the counties of Santa Barbara and Los Angeles, in the southern portion of the State.

The first infested district extends from Menlo Park to San Mateo, a distance of 10 miles. It is bounded on the east by the Southern Pacific Railroad, and extends some 3 miles west, including in consequence some 30 square miles. But little effort, according to Mr. Cooke, has been made to eradicate the pest in this district.

The second infested district is contained within the town limits of San Rafael, Marin County, about 14 miles north of San Francisco. In this district it has been held in check, but there are still some to be found, and its increase is only dependent upon a lapse of vigilance.

The third infested district includes the city of San José and the town of Santa Clara, and contains an area of about 16 square miles. In these towns the scale insects infested the ornamental and shade trees and shrubbery, but did not seem to trouble the deciduous fruit trees to any extent. At San José energetic measures have been taken; the trees have been cut back and their trunks scrubbed until the pest has been thoroughly eradicated. At Santa Clara, however, little has been done, and some places are seriously infested.

The fourth infested district occurs at the city of Sacramento, where only-about 120 acres are infested, although it is stated to be rapidly spreading. The insect was first discovered in this district by Mr. Cooke in October, 1885, in about eight gardens. The city trustees appropriated $200, and with this sum it was destroyed, except upon certain premises which the authorities could not enter. Mr. Cooke gives in this connection, as an instance of the rapidity of the multiplication and spread of the insect, the following:

> In October, 1885, a patch of these insects covered a space of about 3 by 4 inches was noticed upon a limb of an Acacia tree. From these it spread, and in a little more than a year several Orange and Lemon trees and other plants growing closely in an area of about 160 by 80 feet had become seriously infested.

The fifth infested district is found at Healdsburg, Sonoma County, about 65 miles north by west of San Francisco. Here the insect is mainly comprised within the town limits, and infests the shade trees along the streets and the shrubbery in the gardens.

In Mr. Cooke's sixth district the insect cannot be said to exist at present. It comprises a single garden in the town of Saint Helena, Napa County, about 60 miles north by east of San Francisco. It was found upon a rose bush in that place by Mrs. Richard Wood in October, 1882. The bush was destroyed, and the pest has not been found in that section since.

The seventh infested district includes the city of Los Angeles, where the insect is principally confined, according to Mr. Cooke, to the gardens and suburbs on the eastern side of the city. Mr. Coquillett says that as nearly as can be ascertained the insect was first introduced

into Los Angeles in 1878 upon some nursery trees purchased from a San Francisco nurseryman. These trees were planted in a certain nursery, and when the insects were first noticed upon them the owner was requested to burn them. He neglected to do this, and soon after failed in business, and the nursery fell into other hands. The new owner also proved indifferent, and from this point the insects spread into the surrounding orchards, going mainly in the direction of the prevailing winds. Some years ago a tree was found infested at Passadena, 7 miles east of Los Angeles, but it was immediately destroyed, and the insect has not been heard of since. At Pomona, 32 miles east of Los Angeles, the same thing happened in 1883. Two trees were found to be infested and were immediately destroyed, and the insect has not appeared since.

The eighth infested district is at Anaheim, Los Angeles County, 27 miles south by east of Los Angeles. Here the insect is purely local and does not seem to be spreading.

The ninth district is at San Gabriel, 9 miles east of Los Angeles. In the vicinity of this place are some of the largest orange groves in California. In 1880 or 1881, according to Mr. Cooke, a Mrs. McGregory bought a pot-plant in Los Angeles, brought it home, and placed it beside a small Orange near her house. In 1882 the neighboring orange trees were found to be infested with the Cottony Cushion-scale. In the fall of 1883 it was found in some of the larger orchards so abundantly as to cause alarm among the growers. By means of a voluntary tax of five cents per tree, some fifteen hundred or two thousand dollars were raised and expended and the pest eradicated. The most radical measures were used. The trees were cut back to the crotches, the branches burned, and the trunks scrubbed. In 1885, however, the insect was again found, but only in a few trees.

The tenth and last district includes the orchards in and around the city of Santa Barbara. According to Mr. Coquillett the scale was introduced into this district in 1878. A number of trees from the same lot which first introduced the pest into Los Angeles was sent to Santa Barbara at about the same time. Mr. Cooke states that he visited this district in July, 1884, and found Mr. Stowe's orchards (10 miles north of the city of Santa Barbara) the most seriously infested spot in the State. Forty acres, principally of lemon trees, were badly damaged, and over many acres the trees had been dug out and burned. Two miles north of Mr. Stowe's, Colonel Hollister's groves also contained the insect in numbers. About 40 acres were partially infested. The latter gentleman made strong endeavors to rid his groves of the insect, and spent a great deal of money, with only partial success. Mr. Cooke states that the course of the insect between Mr. Stowe's and Colonel Hollister's could be plainly traced over a rolling grazing land on the nettles, dock, and other weeds.*

*Reports have gained currency that this Icerya was found abundantly around Santa Barbara on wild plants, and especially upon the "Grease-wood," and it has been argued from such reports that the species is indigenous. They have no foundation except in mistaken identity, a large Coccid belonging to the genus *Rhizococcus*, which occurs abundantly on *Artemisia californica*, having undoubtedly given rise to the report. The female of this species, which we shall describe as *Rhizococcus artemisiæ*, secretes a globular mass of white cottony wax, which is more or less distinctly ribbed, and her eggs are of the same color as those of the Icerya; but with these superficial resmblances which have misled, there are profound structural differences.

FOOD-PLANTS.

ORIGINAL FOOD-PLANT OF ICERYA PURCHASI.—There seems good reason to believe that this species is originally an Acacia insect, and that upon one or another of the plants of this genus it was imported from Australia into South Africa, California, and New Zealand. Australia is pre-eminently the home of the Acacias, while none are indigenous to California, nor, so far as we can ascertain, to New Zealand, and, as is well known, the species now found in these two countries have been introduced from Australia.

Professor McCoy, of Melbourne, in his original communication to the government of Cape Colony, in 1876, stated that the insect in question occurred in Victoria on "different kinds of Acacia."

Mr. J. C. Brown* states, on the basis of Mr. Trimen's description, that the "Australian Bug" appears to resemble in several details one of the Coccidae found on the Kangaroo Island Acacia, universally around Adelaide. This statement is so indefinite as to have little weight; yet there is more than a possibility that the Australian insect mentioned is the *Icerya*.

Mr. Trimen, in his report previously mentioned, states that the first specimens seen by him in Cape Colony occurred in 1873, at Clairmont, on Blackwood trees (*Acacia melanoxylon*), obtained from the botanic gardens at Cape Town. He goes on to say:

> In the course of a few months the insect increased so prodigiously in number, and the Australian Acacias became laden with them to such an extent, that in the early part of 1874 the large Blackwood trees in the gardens, which were infested to a greater extent than any other plant, had to be cut down.

In New Zealand the first appearance of this insect was also upon an Australian Acacia. Mr. Maskell, in originally describing the insect, in 1878, says: "My specimens of this subdivision were found on a hedge of the Kangaroo Acacia,† in Auckland, in March last. I understood from Mr. Cheeseman and Dr. Purchas, who kindly brought this insect under my notice, that it had only lately appeared in Auckland, and that it was only as yet to be found upon that one hedge."

In California the experience was almost precisely similar. Mr. Stretch, in his paper before the California Academy of Sciences, in 1872, stated that at Menlo Park "it seemed to originate upon *Acacia latifolia*, a species imported from Australia." Miss Anna Rosecrans, writing to the *Pacific Rural Press* of February 17, 1877, says: "It was first noticed at San Rafael on Acacia trees four or five years ago." Dr. Chapin, in the first report of the State Board of Horticultural Commissioners of California, 1882, says: "This scale has been, it is asserted, known to be on the Acacia for seven years in San José, but it is only during the past and present seasons that it has attracted attention" (presumably by its spread to other cultivated plants).

Thus we have much cumulative evidence that the species of the genus Acacia are the preferred food-plants of the Cottony Cushion-scale, and, admitting Australia as its proper home, they are probably its original food.

ITS FOOD-PLANTS IN SOUTH AFRICA.—From Mr. Trimen's 1877 report we gather the following list of plants to which the Australian Bug had spread since 1873:

Acacia melanoxylon.

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*On the "Australian Bug" of South Africa. *Journal of Forestry*, May, 1882. VI, p. 44.

†*Acacia armata.*—C. V. R.

Australian Acacias.
"Golden Willow."
Casuarius.
Pittosporum.
"Blue Gum" (rarely).
Australian "Bottle-brush."
Oak.
Orange.
Vine.
Fig.
Laurustinus.
Rose.
Rosemary.
Strawberry.
Verbena.
Plumbago.
Indian Jasmine.
Bougainvillea.
Hawthorn.
Poinsettia.
Hakea.

This list is not added to in the "Report of the Commission," &c., published at Cape Colony in 1877. Mr. Trimen, in the article cited above, gave the preference to the trees and shrubs of Australian origin; but Mr. J. C. Brown (*loc. cit.*) quotes him as writing, under date of March 17 (1882?), that the insect had then mainly attached itself to the orange trees. "Many of the finest plantations have been destroyed and others are on the high road to destruction. You will remember," he says, "how good and cheap oranges used to be here; they have lately been three pence and four pence apiece, and often inferior in quality even at such a price."

ITS FOOD-PLANTS IN NEW ZEALAND.—From the various communications of Mr. Maskell and others in the Transactions and Proceedings of the New Zealand Institute we give the following list of plants which have been especially designated. There has been no attempt, however, on Mr. Maskell's part to give at all a complete list, and in fact, he says,* "In Auckland it is attacking *all sorts* of plants, from Apple and Rose trees to Pines, Cypress, and Gorse":

Common Furze.
Orange.
Lemon.
Acacia decurrens.
Acacia armata.
Apple.
Wattles.
Rose.
Gorse.
Pine.
Cypress.

ITS FOOD-PLANTS IN CALIFORNIA.—Originally starting upon *Acacia latifolia* at Menlo Park, this insect soon spread to numberless other plants. Dr. Saxe, in 1877, mentioned that it already attacked the Acacias, Australian Pea-vine, Rose, Honey-suckle, Ivy-geranium, Laburnum, Pear, and the weeds in the orchard.

*Ibid., XVI, p. 140 (1883).

Dr. Chapin, in 1883, mentioned the following:
Pear.
Apple.
Bridal-wreath.
Rose.
Dwarf Box.
Verbena.
Veronica.
Acacia mollissima.
Acacia latifolia.
Acacia limnœris.
Acacia floribunda.
Pittosporum tobria.
Strawberry.
Black Locust.
California Laurel.
Cork Elm.
English Ivy.
Magnolia grandiflora.
White Oak.
Dwarf Flowering Almond.
Wild Grease-wood.

Our recent experience in California, as well as that of Messrs. Coquillett and Koebele last summer, would indicate that, while there are few plants upon which the insect will not temporarily feed if it happen to fall upon them while in the first stage, yet the number of plants upon which it can thrive and multiply is limited. The larva will survive for weeks without food and will wander about in search of suitable food if it should find itself, for one cause or another, on that which is unsuitable. It undoubtedly thrives best on Acacias, and next to these we should place the Citrus fruits, the Quince, and the Pomegranate, and we doubt if it could thrive upon many other trees. The list of its food-plants, or rather of plants upon which it has been found, is longer than is justified, not only because of its power of endurance above noted, but because the young are easily carried by wind or otherwise to plants more or less uncongenial and on which they ultimately perish, while the adults are often dislodged from infested Acacia or Citrus trees onto plants under or near them.

Among the more valuable trees upon which it certainly cannot thrive, and upon which it does not occur when they are grown at some distance from infested Acacia or Citrus trees, are the following: Pines, Cypress, Eucalyptus, Olive, Apricot, Peach, Pear, and Oleander.

The plants upon which Mr. Coquillett found females with egg-masses in limited numbers, and which were growing in situations so remote from any infested Acacia or Citrus trees as to preclude the idea that the adult insects had found their way to these plants from such trees, were as follows:
Pomegranate.
Quince.
Apple.
Peach.
Apricot.
Fig.
Walnut.
Locust.
Willow.

Pepper.
Grape.
Rose.
Castor-bean.
Spearmint.
Rose-geranium.

Mr. Koebele, whose observations have been close and extensive, found that the Quince is always thickly infested, as is also the Pomegranate, while on Pear, Apple, Peach, and Apricot the scales were not numerous in the adult state. Only a few scales, and these nearly always small, were found upon the Castor-oil bean. Some Pecan-trees were noticed on which some of the branches were completely covered with scales. A Willow hedge surrounded by plants which had been infested for over two years did not itself become attacked until the past summer. The Fig he states to be a favorite food-plant. On Eucalyptus he found young scales all summer, and in October he found twigs full of scales of all sizes. A few full-grown individuals were found upon a single Pepper tree (*Schinus molle*) growing in the orchard. The following is a supplementary list of plants upon which Mr. Koebele reported the scales most noticeable:

Portulaca oleracea—Scales often numerous.
Malva rotundifolia.
Grape (*Vitis* spp.)—Scales occurring principally on petiole and leaf.
Medicago denticulata.
Helianthus spp.
Rose (*Rosa* spp.)—Scales growing often to an unusually large size, and very numerous on some varieties.
Epilobium coloratum.
Erigeron canadensis.
Bidens pilosa.
Artemisia ludoviciana.
Ambrosia psilostachya—Hundreds of scales on each plant during July, August, and September.
Sonchus oleraceus.
Plantago spp.
Mentha piperita.
Stachys æquata.
Solanum tuberosum.
Solanum douglasii.
Chenopodium murali.
Chenopodium album.
Amarantus retroflexus.
Polygonum persicaria—Stem often entirely covered by scales.
Rumex crispus.
Urtica holosericea—A favorite plant, on which the scales developed with unusual rapidity and to large size.
Carex spp.
Paspalum spp.
Panicum crus-galli.

CHARACTERS AND LIFE HISTORY.

The genus *Icerya* was first described by Signoret in the Annales de la Société Entomologique de France" for 1875, pp. 351, 352, and was founded on the single species *I. sacchari* (Guérin), which occurs on sugar cane at the Island of Bourbon. He knew only two stages, the

full-grown female and the newly hatched larva, but these were described with his customary care.

Mr. Maskell, in describing the species under consideration, places it without much hesitation in this genus, and later, in 1883, still places it in *Icerya*, after examining specimens of *I. sacchari* sent him by M. Signoret. In his original paper (Trans. Proc. N. Z. Inst., 1878, 220), Mr. Maskell describes quite carefully the egg, the young larva, the second stage, and the full-grown female, but had not seen the male larva, cocoon, or adult. Professor Comstock (Ann. Rept. Dept. of Agric., 1880, p. 347) follows Maskell's description quite closely, and introduces no new facts.

There is therefore a necessity for a careful review of the complete life history of the insect, and this we have endeavored to give in the following pages.

THE EGG (Plate II, Fig. 1).—The egg is quite smooth, elongate-ovate in form, and is of a deep orange-yellow color. It measures about 0.7^{mm} in length.

The average number of eggs laid by the female varies according to the vigor of the individual or the condition of the plant upon which she dwells; prolificacy diminishing in proportion as the plant is badly infested—a general law among Coccidæ. Over 800 eggs have been counted in a single egg-mass by Mr. Coquillett, while Mr. Koebele has counted in a single egg-mass, which, by the way, was found upon nettle (*Urtica holosericea*), 940 eggs and 72 young larvæ, while 123 eggs yet remained in the dead body of the female, making a total of 1,135 eggs from the single female.

The time required for the eggs to hatch after leaving the body of the female varies with the temperature. In the winter-time the sacs are usually filled with eggs, while in the hottest part of the summer seldom more than one or two dozen will be found in each sac. Some collected by Mr. Coquillett on the 18th of March did not hatch until the 10th of May; but in mid-summer hatching is only a matter of a few days.

THE FEMALE LARVA—FIRST STAGE (Plate I, Fig. 2, and Plate II, Fig. 2).—The newly hatched female larva (and probably the male is identical with it at this stage of growth, since we have not been able to separate them into males and females) is red in color, inclining somewhat to brown. The body is ovoid in outline, being flattened beneath and convex above. The antennæ are long and 6-jointed. Joint 1 is short and stout, and as broad as long; joints 2, 3, 4, and 5 subcylindrical and subequal, much more slender than joint 1, and twice as long as broad; joint 6 is as long as 4 and 5 together, and forms a long club, at base equaling joint 5 in diameter, but broadening out to twice its width at tip. The basal portion of the club is sometimes distinctly separate from the rest, forming an additional joint. All joints have a few sparse hairs, and the club, in addition to several short ones, bears near its tip four very long ones, each of which is considerably longer than the whole antenna. The legs are thin and brown in color. The coxæ and femora are moderately large, while the tibiæ and tarsi are long and thin, the terminal joints of the latter bearing several long hairs. The upper digitules are represented by simple hairs, but the lower ones are present and are bent near the base. The eyes are prominent and are each mounted on a short tubercle. The mentum is broad and apparently 2-jointed. The rostrum is broad at base and the rostral setæ are not very long. At the tip of the rounded abdomen are 6 small tubercles, 3 each side of tip, each of which carries a

long stout hair, which is as long as the whole body. The body above shows 6 rows of secretory pores, 4 along the middle, and 1 on each side. More or less regular rows of hairs alternate with these pores.

FEMALE LARVA—SECOND STAGE.—According to Maskell and Comstock, there are but three stages of growth in the female after hatching, and these are readily distinguished by the number of antennal joints; the larva of the first stage having 6, that of the second 9, and the adult 11. Messrs. Coquillett and Koebele came to the same conclusions, and all have overlooked a form which we have found quite abundantly among the material we have studied, and which seems to constitute an intermediate stage between the so-called first and second, and which is of course produced by an additional molt which we have personally observed in the field. Hence the so-called "second stage" of these authors becomes third, while the adult female is fourth instead of third, and there are 3 molts instead of 2.

This new intermediate form (Plate II, Fig. 3) differs from the female larva of the first stage in the following respects: It is much more rounded and of a stouter general appearance. The antennæ have the same number of joints, 6, but their relative proportions are quite different. The antennæ as a whole are relatively much shorter. Joint 1 is short and stout, its length equalling its breadth; joint 2 equals joint 1 in length, but is not quite so broad; joint 3 is as broad as joint 2, but is twice as long; joints 4 and 5 are equal in length and width, each narrowing somewhat at base and tip, each considerably narrower than joint 3, and each of the same length as joint 2; joint 6 (club) is of an irregular shape; at base it is as narrow as joint 5, but it broadens until it is slightly wider than 2 or 3, and its tip is narrowed again; its shape is that of an irregular rhomboid with rounded angles and sides, the acutest angles at base and tip. The antennæ carry about the same number of hairs as in the first stage, but those homologous with the four very long hairs of the club in that stage are in this second stage but little longer than the other antennal hairs. The eyes do not appear on the margin of the body, and are only seen on a ventral view. The legs are proportionately much shorter, and the femora are stouter; the trochanters are broader distally, and consequently form a broader triangle in shape. The six tubercles at the anal end of the body are still present, but the hairs which they bear are much shorter. The secretory pores are no longer arranged in rows, but are scattered sparsely over the back and under the sides. The back is more hairy, and the short black hairs occur in irregular tufts.

FEMALE LARVA—THIRD STAGE (Plate II, Fig. 4).—That which has heretofore been considered the second stage, and which, as we have just seen, is the third, may be described as follows:

The body is broadly oval in shape and reddish-brown in color, but is soon obscured more or less by the thick, curly, cotton-like excretion. The antennæ are 9-jointed instead of 6, and are subcylindrical, tapering somewhat from base to tip. Joints 4, 5, 6, 7, and 8 are subequal in length, and each is about as long as broad; joints 2 and 3 are broader and considerably longer; joint 1 is like the corresponding joint in the previous stage; joint 9 (club) is a suboval joint, proportionately much smaller than in the previous stages; it does not exceed joint 8 in width, and it does not quite equal joints 7 and 8 together in length. The long hairs of the club are proportionately quite short. The insect as a whole is much more hairy than in either of the previous stages. The hairs are short and black, and show a marked tendency

to grow together in tufts; even when their bases are well separated their tips turn toward each other or toward the common center of a group; they are quite thickly scattered over the thorax, but less so over the abdomen; all around the edge of the body they appear in close tufts, and the concentric subdorsal ring of tufts which is so prominent in the next stage is plainly seen in this. The secretory pores are scattered irregularly all over the back, and are more numerous than in the previous stage; they also occur under the lateral edges of the body. They are small and circular, and, seen directly from above, have a double outline, indicating a circular central orifice. Around the edge of the body is a row of much larger pores, brown in color, which protrude from the body, masked by the lateral tufts of hairs, each with a circular crown or lip at tip, from which proceeds a long, fragile, glassy tube. (Plate II, Fig. 6.) The legs and feet are a little stouter than before, the tarsal digitules are shorter, and their enlarged tips quite indistinct. The six anal hairs are still present, though hardly noticeable as they protrude from the mass of shorter hairs.

THE ADULT FEMALE—FOURTH STAGE (Plate II, Fig. 5).—Immediately after the molt by which the insect passes into this stage, it is free from the waxy excretion and presents a broadly oval form, flattened below and quite strongly convex above, with two prominent raised surfaces on the second and third thoracic segments. Its color is still reddish brown, with several darker spots, especially upon the front half and along the sides of the posterior half of the body, and the antennæ and legs are black. The antennæ are now 11-jointed instead of 9; joint 1 is nearly twice as wide as long; joints 2 and 3 are subequal in length and thickness and are each somewhat longer than broad; joint 4 is a little more than half as long as 3 and is narrower; joints 5, 6, 7, 8, 9, and 10 increase gradually and slightly in length and decrease very slightly in width; joint 11 (club) is irregularly ovoid and is one and one-half times as long as 10; the special hairs are a little shorter than in the previous stage. The whole body is furnished with short, black hairs, more numerous than in the last stage, arranged in tufts, particularly around the edge, where they occur in a double parallel row, the inner row being practically subdorsal and accentuated by a slight ridge. Down the central portion of the dorsum of the abdomen the segments are indicated by the transverse rows of hair tufts. The secretory pores are exceedingly abundant, occurring in enormous numbers just under the lateral edges of the body, and scattered more sparsely over the back. The individual wax filaments which issue from these pores are very delicate and curly, and there is reason to suppose that two or three issue at one time from one pore, as they are frequently seen connected at base; the pore opening, however, seems to have a single simple opening. The inner row of tufts on the back is broken at its anal point by a depression, in which is situated a very large pore, from which the insect occasionally ejects a globule of a semi-liquid honey-dew. This depression is surrounded by an irregular ring of hairs, which are yellowish in color instead of black. The glassy filaments arising from the large tubular pores described in the last stage are now very long and radiate from the body in almost every direction. They break off easily, yet still often reach a length double that of the insect and her egg-sack together. What is probably the opening of the oviduct is situated on the under side of the seventh abdominal segment. It is surrounded by a transversely oval chitinous ring.

THE EGG-SAC (Plate I, Fig. 4).—As the body of the female begins to swell from the eggs forming inside, the beginning of the egg-sac is made. The female lies flat on the bark, the edges of the body turned slightly upwards, and the waxy material of which the sac is composed begins to issue from countless pores on the under side of the body, but more especially along the sides below. As the secretion advances the body is raised, the cephalic end being still attached, until, near the completion of the sac, the insect is apparently standing on its head, nearly at right angles to the surface to which it is attached. The egg-laying commences as soon as a thin layer of the secretion has formed on the under side of the abdomen, and it continues during the formation of the sac. There soon appears around the edge of the abdomen a narrow ring of white feltlike wax, which is divided into a number of flutings (Plate I, Fig. 3). These flutings grow in length and the mass of eggs and wax under them increases, forcing the female upward until the sac is completed. When completed, it is from two to two and one-half times the length of the female's body. It is of a snow-white color, and the outside is covered with 15 of these longitudinal ridges or flutings, of subequal size, except that the middle one is smaller than the others. The upper part of the sac is firm in texture, but the lower is looser and thinner, and from the middle of the under side the young make their escape soon after hatching. The size of the sac and the length of time required in its growth depends, leaving the weather and the health of the food-plant out of consideration, upon the number of eggs which the female deposits. So long as oviposition continues, the secretion of wax accompanies it and the egg-mass grows. Concerning the rate of growth Mr. Coquillet gives the following instance:

"On the 4th of May of the present season I marked a large number of females which were located upon the trunk of an orange tree that was not in a very healthy condition. These females had just begun to secrete the cottony matter, the latter at this date being in the form of short but broad tufts around the margin of the abdomen, those at the hind end of the latter being longest. By the 31st of May the cottony matter was equal in length to one-third of the female's body, and by the middle of July it about equaled in length the entire body of the female. As the egg-masses of some of the females upon the same tree were longer by one-half than the bodies of the females which produced them, it is very probable that at least another month must elapse before the egg-masses of the females which I observed would be completed. It is altogether likely, however, that these egg-masses would have been completed in a shorter time had the females been located upon a healthy tree. The egg-masses found upon healthy trees attain larger size than those found upon sickly trees, owing doubtless to the fact that the females living upon trees of the former kind are more vigorous than those upon unhealthy trees."

THE MALE LARVA—PROBABLE SECOND STAGE.—Neither Mr. Coquillett nor Mr. Koebele were able to distinguish the male larvæ until these had reached the stage in which they form their cocoons. Among the specimens studied at the Department, and which were sent alive from Los Angeles by Mr. Koebele, we have found a larval form which has not yet been described, and which we strongly suspect may be the male in the second stage. This form is illustrated at Fig. 7, Plate II. It differs from our supposed second stage of the female in its more slender form, longer and stouter legs, and longer and stouter antennæ. The legs and antennæ are not only relatively

longer and stouter, but are absolutely so. The body above is much more thickly clothed with the short stout hairs than the corresponding female stage, and the mentum is longer and darker colored. The antennæ are 6-jointed, and the joints have precisely the same strange relative proportions as in the female. The secretory pores are present, but are not quite so numerous as in the female.

Male Larva—third Stage.—In this, the third or last larval stage, the male is readily distinguished with the naked eye from the female in any stage by the narrower, more elongate, more flattened, and evenly convex form of his body, as well as by his greater activity in crawling about the trunk or branches of a tree. More careful examination shows that the beak is entirely wanting, the tubercle from which it arises in the earlier stages being replaced by a shallow triangular depression. The body is almost naked, being very sparsely covered with a short, white, cottony matter, and is destitute of the short but stout black hairs which are found upon the body of the female during the third and fourth stages of her life. In the absence of black spots and in the 9-jointed antennæ he agrees with the similar or third stage of the female, and the average length when full grown is about 3^{mm} and diameter about 1^{mm}.

The male Pupa and Cocoon.—When the male larva has reached full growth and is ready to transform it wanders about in search of a place of concealment, finally secreting itself under a bit of projecting bark, under some leaves in the crotch of the tree, or even wedging itself down under a mass of females. Very frequently, probably in the majority of cases, it descends to the ground, and hides under a clod of earth or works its way into some crack in the ground. Having concealed itself, it becomes quiescent, and the delicate, flossy substance of which the cocoon is formed begins to exude abundantly from the body. This material is waxy in its character, but is lighter and more flossy and less adhesive than that of which the egg-sac of the female is composed. After a certain amount has been exuded the larva moves backwards very slowly, the exudation continuing until the mass is from 7^{mm} to 10^{mm} in length. From this method of retrogression it happens that the body of the larva is frequently seen protruding posteriorly from the mass, which naturally leads to the erroneous conclusion that the material is secreted more abundantly from the fore part of the body, whereas the reverse is the case. When the mass has reached the proper length the larva casts its skin, which remains in the hind end of the cocoon, and pushes itself forward into the middle of the cocoon.

The pupa (Plate II, Fig. 8) has the same general color as the larva, the antennæ, legs, and wing-pads being paler and the eyes dark. It has also the same general form and size. All the members are free and slightly movable, so that they vary in position, though ordinarily the antennæ are pressed close to the side, reaching to basal part of metathorax(ventrally); the wing-pads also against the side, elongate-ovate in form and reaching to second abdominal joint. The legs are rather shorter than the diameter of body, and the front pair thrust forward. The anal end is deeply excavated, the abdominal joints well separated, the mesonotum well developed, and the pronotum tuberculous or with some 8 prominences; but there are no other structural peculiarities. The surface is, however, more or less thickly covered with waxy filaments, which are sometimes exuded in sufficient quantities to give quite a mealy appearance.

Whenever the pupæ are taken from the cocoon and placed naked

in a tin box they exude a certain amount of wax, often enough to partially hide them from view. If disturbed, they twist and bend their bodies quite vigorously.

The cocoon (Plate I, Fig. 5) is of an irregular elongate shape, appearing a little denser in the center, where the pupa has placed itself, and at the edges delicate and translucent. The material of which the cocoon is composed is very delicate, and appears like the finest cotton, but on submission to a gentle heat it melts as readily as the coarser secretion of the female, and leaves the larva or pupa, as the case may be, clean and exposed.

THE ADULT MALE (Plate I, Fig. 1).—A careful description of the male of this species has never been published. It was unknown to Mr. Maskell at the date of his first paper and has not been mentioned in any of his subsequent papers. Mr. Trimen attempted to breed it, but was unsuccessful. He says: "So little is certainly known of the males of the Coccidæ that I have kept from time to time a large number of this Dorthesia under glass in the hope of obtaining the males, but hitherto without success. I once, however, found on my window a male of some Coccus which I thought was very probably that of the introduced species, as it agreed in most of its important characters with Westwood's figure of the male *Dorthesia characias*. It was dark-red, with the wings gray, and very slender and fragile in its structure. It measured $\frac{1}{4}\frac{5}{8}$ inch across the expanded wings."

The male was unknown to Professor Comstock, but was very briefly mentioned by Dr. Chapin in the first report of the Board of State Horticultural Commissioners, Sacramento, 1882, p. 68. He found the male in numbers during a period of two weeks from September 25, 1881, but did not observe it in 1882. It is also mentioned by Matthew Cooke in his "Injurious Insects," &c., 1883, p. 166, and a rough and uncharacteristic figure is given at Fig. 146, Plate 3. His few words of description are: "Male insect, winged; color, thorax and body dark brown; abdomen, red; antennæ, dark colored, with light hairs extending from each joint; wings, brown, iridescent." The following detailed description is drawn up from numerous specimens, both mounted and living:

The adult male is a trifle over 3^{mm} in length, and has an average wing expanse of 7.5^{mm}. The general color is orange-red. The head above is triangular in shape, with the apex blunt and projecting forward between the bases of the antennæ. The eyes are placed at the other apices of the triangle, and are large, prominent, and furnished with well-marked facets. There are no mouth-parts, but on the under side of the head is a stellate black spot with five prongs, one projecting forward on the conical lengthening of the head, one on each side to a point just anterior to the eyes and just posterior to the bases of the antennæ, and the remaining two extending laterally backwards behind the eyes. The antennæ are light brown in color and are composed of ten joints. Joint 1 is stout, almost globular, and nearly as broad as long; joint 2 is half as broad as 1 and is somewhat longer; joint 3 is nearly twice as long as 1 and slightly narrower than 2; joints 4, 5, 6, 7, 8, 9, and 10 are all of about the same length as joint 3, and grow successively a little more slender; each joint, except joint 1, is furnished with two whorls of long light-brown hairs, one near base and the other near tip; each joint is somewhat constricted between its two whorls, joint 2 less so than the others. There are no visible ocelli. The pronotum has two wavy subdorsal longitudinal black lines, and the mesonotum is nearly all black, except an oval patch on the scutum. The metanotal spiracles are black, and there is a transverse crescent-shaped black mark, with a short median backward prolongation. The mesosternum is black. The legs are also nearly black and quite thickly furnished with short hairs. The wings are smoky black, and are covered with rounded wavy elevations, making a reticulate surface, a cross-section of which would appear crenulate. The costa is thick and brown above the subcostal vein, which reaches costa at a trifle more than four-fifths the length of the wing. The only other vein (the median) is given off at about one-sixth the length of the wing, and extends out into the disk a little more than one-half the wing length. There are,

in addition, two white lines, one extending out from the fork of the subcostal and the median nearly straight to the tip of the wing, and one from the base in a gradual curve to a point some distance below the tip. Near the base of the wing below is a small ear-shaped prolongation, folded slightly on itself, making a sort of pocket. The halteres are foliate, and furnished at tip with two hooks, which fit into the folded projection at base of wings. The abdomen is slightly hairy, with the joints well marked, and is furnished at tip with two strong projections, each of which bears at tip four long hairs and a few shorter ones. When the insect is at rest the wings lie flat upon the back.

RATE OF GROWTH OF THE DIFFERENT STAGES.

The rate of growth of the insect necessarily depends so much upon surrounding conditions, and especially on the mean temperature, that it is difficult to make any definite statements as to time elapsing between molts or that required for other periods of the insect's growth. No facts have hitherto been published which bear upon this point. Mr. Coquillett's observations show that individuals hatched from eggs on the 4th of March cast the first skin on the 23d of April, and underwent the last molt on the 23d of May. Mr. Koebele also reports a case which bears upon this point, and which is interesting as occurring later in the season. He placed four newly hatched larvæ on a healthy young orange tree, out of doors, August 5. On September 26 two of them passed through the first molt. October 10 one more molted, and on October 23 the fourth cast its first skin. All left the leaves after molting and settled on young twigs. None of them had gone through the last molt when he left Los Angeles, November 6. He was afterwards informed by Mr. Alexander Craw, of Los Angeles, that nearly all of the insects were full-grown in February, and he therefore concluded that the individuals observed by him would not attain full growth before that time.

The mature male larva requires on an average about ten days from the time it begins to form the cocoon before assuming the pupa state, and the pupa state lasts from two to three weeks. The more reliable information we have been able to obtain, would show that at Los Angeles the average number of generations each year is three.

HABITS.

The newly hatched larvæ settle upon the leaves and tender twigs, insert their beaks, and imbibe the sap. On passing into the third stage they seem to prefer to settle upon the smaller twigs, although a few are found upon the leaves and still fewer upon the larger branches and trunk. The adults, however, almost invariably prefer the trunk and largest branches.

The insect is rarely found in any of its stages upon the fruit.

The species differs markedly from most Coccidæ in being active during the greater part of its life, though most of the traveling is done by the female immediately after the third molt and by the male just before settling to make his cocoon. At these periods they wander up and down the trunk and larger limbs until they find some suitable place, when they settle down, the male to pupate and the female to insert her beak and develop her eggs and their characteristic waxy covering. She is capable of slow motion even after oviposition has commenced, but rarely does move unless from some exceptional cause. In thus settling after their last wanderings both sexes are fond of shelter and will get under any projecting piece of

bark or under bandages placed around the tree, the male often creeping under clods of earth. Both the female and the male, in adolescence, are most active during the hotter parts of the day and remain stationary at night; but the perfect or winged male is rather sluggish during the day, usually remaining motionless on the under side of the leaves of low plants or high trees, in crevices of the bark, or wedged in between females on the tree. There seems, in fact, to be a well-marked attempt at concealment. The recently developed individuals are found abundantly on or under clods of earth near their pupal cocoons, and they issue most numerously during the latter part of the afternoon. They are at first weak, awkward, and ungainly, and instinctively seek some projection on the tree or elevation on the ground from which to launch on the wing.

At the approach of night they become imbued with a very high degree of activity and dart rapidly about on the wing. At such times they swarm around the infested trees, and many of the females, even some with large egg-masses, hold their bodies raised obliquely from the bark, as though aware of the presence of the males. In September and October Mr. Koebele noticed that the males began their flight about 5 o'clock, and as soon as it was fairly dark they again settled down to rest. None have been observed flying at night and none have been attracted to the electric lights.

EXUDATION OF THE HONEY-DEW.

It required but a few hours upon our first visit to Los Angeles, the latter part of March, to become familiar with the insect in all its habits and conditions, as at that season the species is to be found in all conditions from the egg through all the stages of both sexes. But the characteristic of this remarkable insect which most obviously attracted our attention and distinguished it from all other species of the family, even where there were no gravid females with the fluted cushion, was the saccharine exudation. As with most Aphids and Coccids, this sweet liquid is exuded at all stages of growth, but is most copious from the adult female just before oviposition begins. It is expelled with considerable force from the large pore already described, and in hot weather with sufficient rapidity to produce all the effects of honey-dew. Usually it is limpid enough to soak and discolor the trunk and to drop as it accumulates from the leaves, sometimes being so copious as to remind one of a shower; but at other times, and especially during dry weather, the sugar condenses and forms large drops or masses of white, semi-opaque, sirupy liquid, which adheres to and often completely covers the insect, so that the trunk of the tree looks much as if it had been bespattered with caustic potash or melted stearine. At other times the liquid parts evaporate entirely and leave masses of pure white powdery sugar.

Honey-loving insects seek this sugary secretion in numbers, and it is always followed by the black mold or smut (*Capnodium citri*), which is so universal an accompaniment of all honey-secreting Homoptera, living as it does on the saccharine deposit. The secretion being so very copious from Icerya, the smut is equally thick and copious in her wake. Indeed, the great prevalence of this smut in the Icerya-infested groves of California (rendering it necessary to wash or cleanse the gathered fruit) is as characteristic of the Pacific coast as the rusty effect of the Rust-mite (which is unknown there) is of the orange groves of Florida.

MODE OF SPREAD AND DISTRIBUTION.

The spread of this species will be aided by very much the same agencies that affect the spread and dissemination of other species of scale-insects. We have already, in 1868, in treating of the Oyster-shell Bark-louse of the Apple,* and again four years later,† discussed the principal methods by which such spread is promoted, viz, by the agency of wind and running water; by the young being carried upon birds and other animals, particularly flying insects frequenting the same trees; but primarily by transport upon scions and nursery stock.

In insects like the Coccidæ, where the locomotive power is confined for the most part to a few days in early larval life, the species would be very much restricted in range, and would never pass from one country to another, except by some of the agencies above indicated. Our observations since we first wrote upon this subject, as well as the extended observations of Mr. Hubbard in Florida, and given in the special report on Insects affecting the Orange, as also Mr. Coquillett's observations on the distribution of the particular species in question, all go to confirm the potency of these means of distribution. Thus Mr. Hubbard found that lady-birds (Coccinellidæ), and more particularly gossamer spiders, are active agencies in such distribution. The agency of the wind, as indicated by the more rapid spreading in the direction of prevailing winds, has often been verified. Mr. Coquillett reports: "In the infested part of this city (Los Angeles) is a large vineyard, and on both the north and south sides of it is an orange orchard infested by these insects; but, while the recently hatched insects occur on the vines as far out as the tenth row of grape-vines on the south side of the vineyard, they are not found upon the vines beyond the third row on the north side, the wind, as stated above, blowing from the southwest. No adult females are to be found on any part of this vineyard, and the young insects must have been carried by the wind from the infested orange trees on either side of the vineyard." Our own experience in California showed that similar evidence of the influence of the prevailing wind in promoting the spread of the species is general.

While Mr. Hubbard's observations show that the action of the wind is indirect rather than direct, by influencing the flight of winged insects and the floating of spiders which transport the scale-insects, yet we have every reason to believe that winds have a much more direct influence than is generally supposed, especially in the case of severe storms passing over infested districts at the right season. We laid emphasis on this in our earlier writings, and Mr. Coquillett, while admitting the influence of birds, insects, and water in the transportation of our *Icerya*, lays greatest stress upon the direct agency of the wind. Young scale-insects are not easily dislodged, but where a tree is badly infested there is every reason to believe that they instinctively drop from the terminal twigs, and their specific gravity is so slight, that they may be carried long distances in strong wind currents.

In regard to the influence of birds upon the spread of the Cottony Cushion-scale, Mr. Coquillett observed that whenever the nest of a bird is found upon a tree recently infested with this insect, the latter will be found to be most numerous in the immediate vicinity of the

* First Report Insects of Missouri, p. 15.
† Fifth Report Insects of Missouri, pp. 85, 86.

nest, thus indicating that the young had been accidentally brought there and in considerable numbers by the old birds. There is no doubt also that the irrigating ditches have a very marked influence on the spread of the species, as many of the ditches pass under infested trees, and the waxy secretion serves both to protect the insect from the water and to facilitate floating.

While, therefore, the gradual spread from orchard to orchard is in the main through the agency of other flying insects and gossamer spiders, yet the transportation of the pests to long distances must necessarily be effected through the agency of high winds, birds, and man in commercial intercourse, the latter being probably the only means by which the species have been introduced from one country to another separated by wide ocean areas.

NATURAL ENEMIES.

Birds.—The natural enemies of the Cottony Cushion-scale seem to be very few in number, not only in California but also in South Africa and New Zealand. In South Africa the only bird which is recorded as feeding upon this scale is the common "White Eye" (*Zosterops capensis*), and this is given by Mr. Trimen upon hearsay evidence only: "I have not noticed any of our small birds attacking the *Dorthesia*, but Mr. C. B. Elliott tells me that his boys have observed the little 'White Eye' * * * pecking at them." From what we have been able to learn of the habits of this bird, however, we are inclined to think that it is attracted rather by the abundant secretion of honey-dew and the minute insects caught in it than by the scale-insects themselves.

Neither Mr. Coquillett nor Mr. Koebele observed any bird feeding upon it. The reason for this exemption is probably the copious secretion of wax, which is doubtless distasteful. Several reliable persons report that ducks and chickens feed greedily upon those scale-insects which are dislodged from the trees. On one occasion a brood of six young ducks gorged themselves upon scales which had been washed from the trees with pure water, and on the same day two ducks died. On the day following three more died, while the sixth recovered after an illness of several days. This disastrous effect was probably due to the greed with which the scales were eaten, as they were said to produce no such result with chickens which ate them at the same time.

Predaceous Insects.—The only predaceous insect observed by Mr. Coquillett to feed upon the Cottony Cushion-scale was the larva of a species of Lace-wing fly (*Chrysopa* sp.), which was not bred and cannot be named more exactly.

The Ambiguous Lady-bird (*Hippodamia ambigua*) has been noticed feeding upon the eggs when they were exposed to view by the egg-sac being broken open; but neither this nor any other species of Lady-bird was seen to feed upon the adult insect, although commonly attracted by the honey-dew secreted.

Among the predaceous insects found by Mr. Koebele and sent to us for study we may mention first the larva of a small moth (*Blastobasis iceryœella* n. sp., Plate III, Fig. 3), although as yet we are not certain that it ordinarily preys upon the living and uninjured scale-insects or their eggs. Like certain other so-called predaceous Lepidoptera, it may be attracted primarily by the waxy secretions of the bark-lice, and only incidentally destroy the insects and their eggs.

These larvæ were often found feeding in the egg-masses of females which had been destroyed by soap washes, and also in sacs the eggs of which had hatched some time previously, but never upon fresh eggs. One of the larvæ, kept in a glass tube with living scales and fresh eggs, fed slightly on the waxy mass, but did not thrive until after the scales died. It then fed upon the dead scales and molted, but died before transforming. Two nearly full-grown larvæ fed readily on dead scales which were still soft, and passed through their transformations successfully. The same insect fed readily upon the Black Scale (*Lecanium oleæ*), in this case eating the living insects and their eggs, forming a silken tube along the twig, and passing from one scale to another, just as does the Coccid-eating Dakruma (*Dakruma coccidivora*)* in feeding upon the Cottony Maple Scale at the East.

This is probably the same insect as that mentioned by Professor Comstock, Annual Report Department of Agriculture, 1880, p. 336, as follows: "Upon one occasion (August 25, 1880), I found within the body of a full-grown female [of *L. oleæ*] a lepidopterous larva. * * * The specimen, however, was lost, and no more have been found since." From the fact that this larva destroys living Black Scales, we have every reason to believe that it will also feed upon living Cottony Cushion-scales, and will not confine itself, as heretofore observed, to the dead females and their empty egg-sacs.

Blastobasis aphidiella, Riley MS., we have reared from the larvæ feeding on the contents of Phylloxera hickory galls.

The genus *Blastobasis* Zeller is distinguished by the first antennal joint being compressed and much broader than the flagellum; its lower side concave, the anterior edge above its base furnished with erect hairs; its apex above provided in the male with a scaly tooth; the flagellum in the male is filiform, faintly serrate, and furnished with short ciliæ, its base curved and anteriorly excised; in the female it is simple. The palpi are as long as thorax and rather stout in the male, faintly compressed and covered with coarse scales, the last joint slightly over half the length of the middle one and its apex pointed. The ocelli are present. The front wings are narrow, their apical portion quite slender and pointed; eleven-veined, vein 1 *b* distinct. The hind wings have seven well-separated veins. This is not the place to discuss the variation which the species of the genus are subject to; but they are small in size, quite uniform in general color and markings, but varying so in the intensity and the details of ornamentation that the species are not easily separated, and we shall not be at all surprised if future experience should justify the combining of several which are now separated.

BLASTOBASIS ICERYÆELLA n. sp.—Expanse 13mm to 15mm. General color pale cinereous. *Head* gray; eyes dull black, fringed posteriorly by rather long yellowish hairs, which curve over them like eyelashes; palpi above pale yellowish-gray; in some specimens the inferior surface is almost black, whilst in others there is only a slight sprinkling of blackish scales; antennæ uniformly gray, with a slight yellowish tinge and faintly darker annulation, the tuft of the basal joint almost white. *Primaries* cinereous, sprinkled quite densely with blackish scales; a linear, blackish, transverse band more or less distinct (in one male only indicated by a small dusky spot at costa), starting from basal third of costa and obliquing posteriorly, it terminates at about the middle of inner margin; its inner edge is bordered by a more or less distinct paler gray line; the black discal spot, which in other species is usually

*We have bred a species of *Dakruma* the past season, indistinguishable from *D. coccidivora*, from the Cochineal insect (*Coccus cacti*) received from Dr. A. F. Carrothers, of San Antonio, Tex., who collected the specimens at his ranch (Iuka ranch) near Cotulla, La Salle County, Texas.

external of the band, in this species forms part of the band; the two black spots on a transverse line with anal angle are always present, though the posterior one is sometimes more or less obliterated; these spots are generally relieved posteriorly by a patch of paler scales, while posteriorly and exteriorly of this pale patch the black scales are sometimes increased so as to resemble a transverse posterior band with a pale interruption. Under surface uniformly gray, with slight brassy reflection. Secondaries pale gray above, glossy below, with brassy reflection. Fringes of all wings still paler, with a yellowish, silky luster. Legs pale gray, the anterior or external surface of the front and middle legs, including coxæ, being in some specimens dark gray or almost black, while in others there is only a slight sprinkling of darker scales. In one specimen there is noticed a quite dark band near the apex of the middle tibiæ; hind legs whitish, sometimes with a faintly dusky, longitudinal streak externally on the tibiæ; abdomen of a lighter or darker silvery gray, generally somewhat darker towards the end, the anal tuft of the male more or less yellowish.

Described from four ♂s and one ♀ reared from Icerya-feeding larvæ.

We have not seen good specimens of this larva, and may therefore quote Mr. Koebele's brief description, drawn up from fresh specimens:

The larva while young is of a reddish-white color, with a narrow, deeper red dorsal line. The piliferous warts are prominent, whitish, with rather stiff white hairs. The head and prothoracic shield are light yellow (testaceous), and bear also a few hairs. The full-grown larva is from 5^{mm} to 6^{mm} long and brownish in color. The narrow, whitish dorsal line is bordered with a mottled liver-brown, and the whitish line beneath this again with a heavier brown subdorsal line. The under side and the feet are still reddish-white, while the head and prothoracic shield are pitch black.

This species is closely related to *Blastobasis chalcofrontella*, and also somewhat to *Blastobasis quisquiliella*, from both of which, however, it may at once be distinguished by the blackish band of the front wings, which in them is wanting or only indicated by a small dusky shade at the costa. The head of *B. chalcofrontella* is also broader and of a yellowish-white color, and the palpi and legs more concolorous with the body, and the general tint of the wings more yellowish.

In *B. quisquiliella* the head, palpi, and legs are more rufous and the general aspect more like *B. chalcofrontella*.

With *B. nubiliella* and *glandulella* it cannot be confounded, as both are generally larger and darker, though some specimens of *nubiliella* are larger than the smaller specimens of *iceryæella*. The band on primaries of *nubiliella* instead of being linear broadens towards the costa so as to form a transversely elongate, triangular spot, which in some particularly well-marked specimens is quite conspicuous.

In *B. glandulella* the band is not indicated or but faintly indicated, and it is at once distinguished by the much larger size and uniformly darker coloration.

A common Tenebrionid beetle (*Blapstinus brevicollis* Lec., Plate III, Fig. 2) was found by Mr. Koebele to occur abundantly among the rubbish at the foot of the trees infested by Icerya. Egg-sacs which had been completely eaten out and the eggs devoured were found in close conjunction with several of these beetles, and in consequence a few beetles were placed in a pill-box with female scales and large egg-masses. In a few days the eggs were all eaten, but the insects themselves were not disturbed. It is probable that this is not the normal habit of this beetle, yet it may without much question be put down as an occasional destroyer of Icerya eggs. The habits of the allied *Epitragus tomentosus*, as described by Mr. Hubbard in his report on Insects Affecting the Orange, p. 75 (Fig. 36), render this all the more probable. The *Epitragus* was observed to feed upon

scale-insects of all kinds in Florida, tearing the scale from the bark and devouring its contents, and sometimes also the substance of the scale itself.

The larva of a Dermestid beetle (*Perimegatoma cylindricum* Kirby, var. *angulare*) was also found among the Cottony Cushion-scales, but as it would only feed on dead scales in confinement, it is not likely that it is truly predaceous.

Prominent among the true bugs found upon the infested trees is the large brown *Largus succinctus* (Plate III, Fig. 4). This is said to destroy the scale-insects, although Mr. Koebele could never see it do so. He noticed it feeding upon the honey-dew, and on one occasion noticed two immature specimens with their beaks inserted in a male larva of Icerya. They ran away on his approach, and the larva was found to be dead; but, as there were numbers of other dead larvæ about, he did not consider that there was any evidence of the predaceous habits of the *Largus*. On the contrary, he observed this insect often with its beak inserted into young shoots of Orange. The other Heteroptera found by him among the scales were the well-known *Piesma cinerea* Say, *Corizus hyalinus* Fabr (Plate III, Fig. 5), *Peritrechus luniger* Say, *Beosus* sp., *Lyctocoris* sp., and *Piezostethus* sp. These last five species have been kindly examined by Mr. Uhler, our best authority in the suborder, and he reports the undetermined species as probably new.

The most efficient destroyer of the Cottony Cushion-scale at Los Angeles is perhaps a species of earwig, family Forficulidæ (Plate III, Fig. 6), neither the genus nor species of which we are able to determine, from the fact that we have only seen immature specimens. According to Mr. Koebele this insect is often met with among the scales, and, from observations which he made, feeds greedily upon the Icerya in all stages, tearing open the egg-masses and eating the eggs, and also tearing and eating the mature insects as well as the larvæ. The breeding habits of the mother earwig and her care of her flock of young have been observed by Mr. Koebele, but have been so well studied by European authors as to need no detail here.

Mr. Koebele also reports the occurrence in the scale masses, in large numbers, of a minute whitish mite, which becomes of a reddish color when full fed, and which he thinks destroys the female scales. We have not seen specimens of this mite, and are therefore unable to determine it.

In a recent communication from Miss Ormerod, already mentioned on p. 467, she writes as follows of a predaceous insect discovered by her correspondent, Mr. Bairstow, of Port Elizabeth, Cape Colony:

> It will perhaps be of some interest to mention that Mr. Bairstow has found a species of Coccinella which has proved (as far as our coleopterists are aware) to be previously undescribed, to be so exceedingly serviceable in destroying the "Australian bug," as they call it, that he has been supplying it to applicants. Dr. Baly examined the specimens sent over for me, and I propose to notice it, with full technical description and a figure, as *Rodolia iceryæ*.

PARASITES.—It is a somewhat remarkable fact that no true parasites were ever bred from the Cottony Cushion-scale until the past summer, and still more remarkable that in the course of their careful investigations, extending over a space of six months, neither Mr. Coquillett nor Mr. Koebele succeeded in finding a single parasite upon this insect. From a number of scales, however, sent to Washington by Mr. Koebele November 10, we bred, on December 8, two specimens of a small Chalcid, which is, without question, a true parasite of

Icerya, as the female scales from which they escaped were found each with a small round hole in its back.

This little parasite (Plate III, Fig. 1) is prettily marked with black and yellow. It is new to our fauna and may have been imported with its host. We turned it over to Mr. Howard for study, and as he finds it necessary to erect a new genus for it, we append his generic and specific characterizations:

ISODROMUS n. g., Howard.

Female.—The antennæ arise near the border of the mouth; the scape is not widened; *the pedicel is much longer than the first funicle joint;* the funicle joints increase slightly in length from 1 to 6 and considerably in width, so that joint 6 is more than twice as wide as joint 1; the club is half as long as the funicle and is obliquely truncate from base to tip. The head is thin antero-posteriorly; the facial impression is slight; *the inner borders of the eyes are nearly parallel*; the ocelli are placed at the corners of a right-angled triangle. The scapulæ meet on a long line at middle. The hind femora have a very delicate longitudinal furrow below. The marginal vein of the fore wings is entirely wanting; the stigmal is moderately long and *bends abruptly downward, forming at first a right angle with the submarginal,* afterwards curving slightly outwards; *the postmarginal is absent. The large mesopleura are covered with a number of longitudinal ridges.*

Male unknown.

This genus belongs to the *Encyrtinæ*, and is more closely related to *Homalotylus* than to any other described genus. Its structural affinity to this genus is quite marked, but it is well separated by the characters italicized above. It differs in habit also, as *Homalotylus* is parasitic upon coleopterous larvæ of the families Coccinellidæ and Chrysomelidæ.

ISODROMUS ICERYÆ, n. sp., Howard.

Female.—Length 2.2^{mm}; expanse 4.2^{mm}; greatest width of fore wing 0.7^{mm}. Head and thorax nearly smooth; head very delicately punctured and furnished with a very few larger impressions. Pronotum and mesonotum very delicately shagreened; mesoscutum and hind border of pronotum with a number of closely applied white hairs. The general color is shining black; all of the head except eyes and an occipital black blotch, the hind border of both pronotum and mesoscutum, all of the tegulæ except tip, a blotch each side of the mesoscutellum and one at tip, the under side of thorax and base of the abdomen, the upper side of the first abdominal joint, and a small spot at the abdominal spiracles, yellow. The yellow of the head is nearly orange, while the rest is more of a lemon. The antennæ are honey-yellow throughout, becoming dusky towards tip. All the legs, including coxæ, are yellow; hind femora dark above, black at knees; hind tibiæ with two black bands. Wings clear. Described from 2 specimens.

REMEDIES AND PREVENTIVE MEASURES.

We have indicated in the introduction to this report the more important results of the experiments carried on at Los Angeles by Messrs. Coquillett and Koebele, and as their reports are later given in full we shall refrain from entering into detail here, and state only a few of the more important convictions that impressed us after the first week's experience in the orange groves of California.

IMPORTATION OF PARASITES.—The general importance of the introduction of parasites which affect a species in its native land, and which have not accompanied it into the land of its introduction, has been insisted on in our earlier writings and in those of others, and the ease with which this may be done in the case of the more minute parasites of scale insects adds to its importance in their connection. Considering the fearful losses already occasioned to California

orange-growers by two species (the *Icerya* in question and the California Red Scale), introduced from Australia, we know of no way in which the Department could more advantageously expend a thousand dollars than by sending an expert to Australia to study the parasites of the species there and secure the safe transport of the same to the Pacific coast; and the fact that the Commissioner of Agriculture is prevented from doing so by restrictions imposed on the Division of Entomology is a sad commentary on the narrow Congressional policy which seeks to limit and control administrative action in details which can neither be properly understood nor anticipated by committees.

Preventive Action.—The value of clean culture and fertilizing where necesary to induce vigorous growth, but more particularly of wise pruning, so as to let in the sun and rain to the heart of the tree, has been set forth in the special report of the Division on the Insects affecting the Orange, by Mr. Hubbard, and apply equally to California as to Florida. We have also been particularly impressed with the value of wind-breaks of coniferous trees not affected by the Coccidæ that infest the Orange, both as shelter to the trees and as screens to prevent the spread of the *Icerya* from infested trees outside the grove.

Spraying with Insecticides.—The orange-growers of the Pacific have suffered greatly from the advice and recommendations of biased or interested persons, who were prejudiced in favor of their own particular remedies, and were for a long time unwilling to profit by the results of thorough and careful experiments which we have for some years conducted in the East, and which are in the main embodied in Mr. Hubbard's report. A pretty thorough personal survey of the field has convinced us that while the resin soaps experimented with by Mr. Koebele are a valuable addition to our insecticides for the orange Coccidæ, yet in the main our experience in Florida is repeated in California, and all the more satisfactory washes have kerosene as their effective base. There has been, and is, however, a very great waste in applying it, and where from 10 to 50 or more gallons have been used on a single tree, from 2 to 4 would suffice.

We cannot urge too strongly the fact that in the case of this *Icerya*, as most other orange-feeding Coccidæ, it is practically impossible, with the most careful and thorough spraying, to reach every one of the myriad individuals on a good-sized tree. Some few, protected by leaf-curl, bark-scale, or other shelter, will escape, and with their fecund progeny soon spread over the tree again if left unmolested. Hence two or three sprayings at intervals of not more than a month are far preferable to any single treatment, however thorough; and this is particularly true of the *Icerya*, which occurs on so many other plants, and which in badly infested groves is crawling over the ground between trees. It is now the custom to use the time of a team and 2 men for fifteen to twenty minutes or more, and 10 gallons and upward of liquid on a single medium-sized tree. In this way the tree is soaked until the fluid rains to the ground and is lost in great quantities, some growers using sheet-iron drip-plates around the base of the tree to save and re-use the otherwise wasted material. This is all wrong so far as the oil emulsion is concerned, as the oil, rising to the surface, falls from the leaves and wastes more proportionally than the water.

The essence of successful spraying of the kerosene emulsion consists in forcing it as a mist from the heart of the tree first and then

from the periphery, allowing as little as possible to fall to the ground and permitting each spray particle to adhere. It is best done in the cool of the day, and, where possible, in calm and cloudy weather. With one-fifth of the time and material now expended in California the spraying should be successfully done, so that three sprayings at proper intervals will be cheaper and far more satisfactory than only one as ordinarily conducted. In this particular neither Mr. Coquillett's nor Mr. Koebele's experiments are entirely satisfactory, as we were so far from the field while they were being carried on as to render any special direction of them impossible. Both strove for the practically impossible, viz, the destruction of all insects by a single application. Mr. Koebele's estimate of the cost of the kerosene wash is also too high, as he used it much stronger than necessary. The resin compounds may doubtless be used to advantage in connection with the kerosene emulsions; but anything which will give permanence and preventive character to the wash will add greatly to its value. Without going into details as to reasons, we would therefore recommend the addition to every 50 gallons of the kerosene-soap wash, made after the usual formula, 3 ounces of arsenious acid. Though the arsenical preparations are mainly effective against mandibulate insects, by poisoning through the stomach, they have also more or less effect by contact, and we are strongly of the opinion (which we hope soon to verify) that this combination, for the first time recommended, will give the spray more lasting effect, and that the few insects which escape the direct spray will be destroyed as they subsequently leave their protecting retreats or hatch from eggs and crawl about the tree. As a means of arresting the growth of the black-mold (which is, however, only the indirect consequence of the Coccid), so troublesome an accompaniment of the *Icerya*, a small proportion of sulphate of copper might also be added.

Just as there is now a great wastage of time and material in drenching a tree, so the spraying nozzle most in vogue in California is also wasteful. That most commonly used is the San José nozzle, in which the water is simply forced through a slightly flaring terminal slit in a more or less direct and copious jet. The force and directness of the spray give this nozzle its popularity under the mistaken spraying notions which prevail, and to this we must add the fact that, being a patented contrivance, it is well advertised and on the market.

The cyclone nozzle has not yet had proper trial to impress its advantages, having scarcely been known prior to the experiments of Messrs. Coquillett and Koebele. That made and sold by G. N. Milco is patterned in size and aperture after that which we designed to spray from near the surface of the ground. What is wanted for an orange grove or for trees is a bunch of nozzles of twice the ordinary size and capacity, the size of the outlet to be regulated by the force of the pump. There is no form of nozzle so simple and so easily adjustable to all purposes. We strongly recommend a bunch of four nozzles of twice the ordinary size and thickness, one arranged so as to have the outlet distally or at one end of the piping (which may be ordinary gas-pipe) and the other three on branches, so that the outlet is at right angles, each about an inch below the other, and so placed that they are separated by one-third the circumference of the main pipe. Such a bunch, with apertures properly adjusted to the occasion, worked from the center of the tree, will envelop it in a perfect ball of floating mist, which in a very short time will imbue all accessible parts. For tall trees a more forcible direct spray might be sent

from the end by substituting an ordinary jet and the wire extension, which is simply an extension tube screwed over the nipple, the end of the tube being covered with wire netting, which breaks up the liquid forced through it, and which for force and fine division of the particles has some advantages over the San José nozzle. Finally, if a series of blind caps and several sets of caps of varying aperture are kept on hand, the spray may be adjusted at will, and to suit the conditions of wind, pump force, &c., that have to be dealt with.

FUMIGATING.—Fumigating the trees will always have the disadvantage, as compared with spraying, that the mechanism is more cumbersome, the time required greater, and the first cost in making preparation heavier; and these factors will always give spraying the advantage with small proprietors or those who have to deal with young trees. As an offset to these drawbracks fumigation has the merit of more effectually reaching all the insects upon a tree, and this alone would under some circumstances justify the greater first cost and trouble in preparing movable tents for the purpose, providing always that a gas, vapor, or fume be discovered that will rapidly kill all the insects without injuring the tree; virtues not easily combined in such subtile media.

In Florida proper spraying has been found to be so effectual and satisfactory that no elaborate experiments in fumigating have been undertaken, and we are fully satisfied that proper spraying will also prove sufficient in California. But so much poor work has been done and so many defective washes used that many growers have become discouraged, and quite a disposition has been shown to either cut down the trees or resort to fumigation as a last resource. In connection with Mr. Alexander Craw, Mr. Coquillett has conducted some experiments in the Wolfskill orchard at Los Angeles, which lead them to believe that they have discovered a gas which possesses the requisite qualities, and trees that had been treated and which we examined pretty carefully would seem to justify their hopes. Several ingenious movable-tent contrivances are also being developed in Los Angeles County that give promise of practical utility and feasibility, and which we may have more to say about on some future occasion.

BANDAGES AROUND THE TRUNK.—There is always danger that a tree once sprayed will get reinfested from the insects that have not been reached upon adjacent plants or upon the ground, and which in time crawl up the trunk. Any of the sticky bandages used for the canker-worm will check this ascent, but when placed directly on the trunk may do more harm than good. They should be placed upon strips of tar or other stout paper or felting, tied by a cord around the middle, the upper end flared slightly outward, and the space between it and the trunk filled with soil, to prevent the insects from creeping beneath. Cotton should not be used for this purpose, as birds for nesting purposes carry away particles of it containing the young insects, and thus help to disseminate them.

CONCLUSION.—All possible care should be taken in cultivating and harvesting the crop to prevent dissemination of the young upon clothing, packing-boxes, &c., and too much care cannot be exercised in endeavors to prevent the introduction of the species from infested to non-infested regions. Next to destructive locusts no insect has been more fully legislated against than this *Icerya* in California. Yet while some good has resulted, the laws have too often proved inoperative, either through the negligence or ignorance of the officers appointed to

execute them, or, more often, the indifference of the courts and their unwillingness to enforce them with vigor.

The pest has come to stay. No human endeavor can exterminate it. But it may be controlled, and while the greatest possible co-operation should be urged and, if possible, enforced, yet each orange-grower must in the end depend upon his own exertion; and we say to them, individually and collectively, that there is no occasion for discouragement. This insect has made profitable orange-growing on the Pacific coast more difficult and more of a science; but, by making it impossible at the same time for the shiftless to succeed in their business, it will come to be looked upon as a not unmixed evil.

BUFFALO GNATS.

Order DIPTERA; family SIMULIDÆ.

[Plates VI, VII, VIII, and IX.]

For many years past one of the greatest insect foes the stock-raisers of the lower Mississippi Valley have had to contend with has been the so-called Southern Buffalo Gnat. This insect is a small fly, closely related to the well-known "Black Fly" of the North, to the famous "Columbacz Gnat" of Hungary, and to other less known but as noxious species of the genus *Simulium*, found abundantly in Lapland, Brazil, and Australia. These flies swarm at certain seasons in immense numbers, and by their bite, multiplied a thousand fold, cause great destruction amongst mules, horses, cattle, hogs, sheep, and poultry.

Although we possess in the United States a great number of species of the genus *Simulium*, only a few of them are so very troublesome and noxious as to have attracted special attention. The great majority of the species are quite local, and occur only in such limited numbers as not to form swarms of sufficient strength to occasion any serious damage, although they are very troublesome at times in some regions. The popular name "Southern Buffalo Gnat" includes at least two distinct species, and others will doubtless be found to contribute to the injury when the regions are better studied entomologically. In any general account of the distribution of the Southern Buffalo Gnats it must be borne in mind that these two species are frequently called by the same name, and that even other flies not at all related to them are called Buffalo Gnats by the inhabitants of the infested regions.

Although two or more species of *Simulium* are thus confounded, the following general statements will describe the actions of all species. They resemble each other in their life-history so closely, that one description of it will apply to that of all.

The popular name Buffalo Gnat has not been chosen because these gnats ever attack the animal of that name, but because of a fancied resemblance to the shape of the same. Looking at the insect from the side, it reveals a very large, hump-backed thorax, with the head—furnished with two short antennæ, like minature horns—in the act of butting an enemy. The name "Turkey Gnat," however, has been given to one of the species concerned, because it appears at a time when turkeys are setting and suffer so much by them. "Goose Gnat" is another name used for the same insect for a similar reason.

Believing that it is always best in popular nomenclature to adopt names already known and given by the people, we shall throughout

this article designate the chief depredator as the "Southern Buffalo Gnat" and the second one as the "Turkey Gnat." We shall treat first of the "Southern Buffalo Gnat," but as both species occur to a great extent through the same region, most of what is said of the one species will apply also to the other, their habits being essentially the same. We shall call particular attention to the "Turkey Gnat" only when it is necessary to show any differences, whether as to distribution, habit, or character.

THE SOUTHERN BUFFALO GNAT.

(*Simulium pecuarum* n. sp.)

GEOGRAPHICAL DISTRIBUTION.

The region infested by the Southern Buffalo Gnat is much more extensive than formerly known. In some years at least it comprises the whole of the Mississippi Valley from the mouth of the Red River, in Louisiana, to Saint Louis, Mo. All the land adjacent to the many rivers and creeks that empty from the east and the west into the Mississippi River is invaded by swarms. They are driven about by the wind, and reach points far away from their breeding-places. The exact localities reached by such swarms can as yet not be given, but may be mapped out after further investigations.

In *Louisiana* all the land inclosed by the Mississippi and Red Rivers, with perhaps the exception of the extreme western counties, is usually invaded by the Buffalo Gnats during a gnat year. South of the Red River they become scarce, less aggressive, and appear only at very irregular intervals.

In *Mississippi* all the counties bordering on the river that gives the name to the State are more or less invaded during gnat years.

All *Arkansas*, excepting perhaps the western counties, shares the same fate. In the numerous creeks and rivers of this State and of Louisiana the Buffalo Gnat breeds most abundantly.

In *Tennessee* the same conditions prevail as in Mississippi, but the swarms do not reach so far east as in the latter State.

In *Missouri* the Buffalo Gnats infest only the southeastern counties.

Kentucky does not fare as well as Missouri, since swarms of them frequently ascend the Ohio River for some distance.

Illinois and *Indiana* are also more or less invaded; in the former, it is the region bordering upon the Mississippi and Wabash Rivers; in the latter, that on the Ohio and Wabash Rivers. In 1886 Buffalo Gnats appeared in large swarms at De Soto, in Jackson County, Illinois, and along the White River, in Davies County, Indiana.

In Eastern *Kansas* swarms have repeatedly done great damage.

EARLY HISTORY.

From the very fact that the Buffalo Gnats have been constantly denominated by the same term, inevitable confusion must necessarily exist in their early history. Such is indicated by the appended reports of the special agents, who of course could not tell to which of the species the information received applied.

It seems that no authentic record exists in Louisiana about the occurrence of the Southern Buffalo Gnat prior to the year 1850. It has been reported, however, that they had previously appeared in 1846.

In 1861 and 1862 they were very troublesome in portions of Mississippi and Louisiana; in 1863 and 1864 they abounded about Shreveport, La., and in Chicot County, Arkansas. None are reported to occur in 1865, but in 1866 they invaded the alluvial country between the Arkansas and Red Rivers east of the Washita. In 1873 and 1874 serious injury was occasioned by them in several regions in Louisiana. But in 1882 and 1884 they were more destructive than ever before, doing immense damage to live stock of all kinds. Although not generally very numerous in 1885, they appeared in sufficient numbers in several counties of Louisiana to kill quite a number of mules. In 1886 they appeared generally throughout the whole extent of the region infested by them, and they appeared rather unexpectedly, because it was so unprecedentedly late in the season.

In Indiana this insect was well known as far back as 1843, when the settlers used to watch for it every year, as swarms would appear in certain regions with more or less regularity, often occasioning considerable damage.

It was ascertained from a number of gentlemen in Tennessee and Mississippi that the Buffalo Gnats were well known to their ancestors who first settled in that region at a time when Indians were their neighbors.

But every one questioned in the States of Louisiana, Mississippi, Tennessee, and Arkansas would voice this universal opinion, viz, that Buffalo Gnats come only with high water and are contemporary with an overflow. The connection between an overflow and the appearance of the Buffalo Gnats will be considered farther on.

TIME OF APPEARANCE.

The time of the appearance of the Southern Buffalo Gnat is regulated by the earliness or lateness of spring, and it consequently appears much earlier in the southern parts of the Mississippi Valley. As a rule, it can be expected soon after the first continuous warm spell in early spring. The first swarms were observed last year in Louisiana on March 11; in Mississippi and Tennessee, May 1; and in Indiana and Illinois, May 12. Small and local swarms may appear somewhat earlier or later in the neighborhood of their breeding-places. The Turkey Gnat appears usually later, although in 1886 it appeared near Memphis, Tenn., as early as April 5; the swarms were quite local, however, and strictly confined to the vicinity of creeks that produced them. In Louisiana they appeared, as usual, much later than the true Buffalo Gnat, and some were found as late as June 6, and the bayous disclosed others still in their pupal state.

The great majority of the species of this genus are northern insects, and appear there in the winged form all through the summer. The larvæ require cold water for development. As we go farther south this *cold water* can only be found in the more elevated regions or in winter or the early months of spring. Earliness of season or high altitude are there the substitutes for the lower temperature of more northern latitude.

DURATION OF AN INVASION.

Swarms of Buffalo Gnats usually appear with the first continuous warm weather of early spring. They lead a roving kind of life, being drifted about with the wind, which frequently carries them long

distances beyond their usual haunts. At first the members composing a swarm are very active and blood-thirsty; but they soon die, and the swarm decreases gradually and soon disappears entirely. New swarms appear continually and replace the former ones. The duration of an invasion throughout the regions infested varies from a few days to five or six weeks. If cold weather follow their appearance, the gnats become semi-dormant; they are not killed by it nor by rain, but revive and become aggressive again with the first warm rays of the sun. Hot weather, however, soon kills them and puts an end to any further injury. The duration of life of a single individual is short; at least specimens confined even in large and well-lit boxes soon die. Buffalo Gnats that have once imbibed blood of any animal also soon die, as seen by the large numbers found dried up in stables in which they have been carried attached to mules or horses. In the fields gnats filled to repletion with blood drop to the ground and crawl away, soon to die. They suffer, therefore, from their blood-thirsty habits, and this seems to be quite a general rule with all those blood-sucking species which are known to annoy man and other warm-blooded animals; for the love of blood generally proves ruinous to those individuals which are anxious to indulge in it, as we have shown to be the case with the Harvest Mite or Jigger.*

CHARACTER OF A SWARM.

The number of individuals comprising a swarm cannot be computed, as swarms vary greatly in size. Their presence is at once indicated by the actions of the various animals in the field. Horses and mules snort, switch their tails, stamp the ground, and show great restlessness and symptoms of fear. If not harnessed to plow and wagon they will try to escape by running away. Cattle rush wildly about in search of relief. Formerly, when deer were still numerous, they would be so tormented by these insects as to leave their hiding-places and run away, seeking protection even in the presence of their greatest enemy, man. Approaching animals in the field, we notice at once small black bodies, exceedingly swift in their flight, darting about their victims in search of a suitable spot to draw blood. But even during a very general invasion by these gnats these insects are not uniformly distributed throughout the region infested, but they select certain places. Only low and moist ground is frequented by them; exposed or sunny spots are never visited. There may be no indications of gnats in a whole neighborhood, and the unprepared farmer, dreaming of no danger to his mules or horses in passing dense thickets of bushes, &c., near the roadside, is suddenly attacked by a swarm of these pests, and is frequently unable to reach a place of safety in time to save his cattle. As suddenly as such swarms appear, just as suddenly do they disappear. During a gnat season cautious farmers never travel with their horses or mules without providing themselves with some kind of protective grease.

When Buffalo Gnats are very numerous the whole air in the vicinity of our domestic animals is filled with them at times, and looking towards the suffering brute, one sees it surrounded by a kind of haze formed by these flying insects. Sweeping rapidly with the hand through the air one can collect hundreds of gnats by a single stroke. They crawl into everything, and the plowman has constantly to brush

*See *Amer. Naturalist*, vol. vii, 1873, p. 19.

them away from his face, which does not always prevent them from entering and filling his mouth, nose, and ears; he is so tormented by them, and frequently by their bite as well, that he has to cease working for the time being. Thousands try to enter the houses in villages and cities, and the windows are frequently completely covered with them.

MODE OF ATTACK.

The flight of all species of *Simulium* is very swift and powerful. They possess, in comparison with most other flies, an enormously large thorax, consisting of a very tough, chitinous integument, that furnishes ample attachment for the strong muscles which propel them during their long and continuous flights.

The Southern Buffalo Gnat is exceedingly active in all its motions, and is at its bloody work as soon as it has gained a foothold upon an animal. The individual flight is inconspicuous and rarely more than a few feet from the ground. It is also usually noiseless, but when one passes rapidly close to the ear of a person the sound produced is faintly like that of a passing bullet, and no one who has listened to it will ever forget it, but will always connect it with their presence.

If the insects are not very hungry, or if influenced by too warm or too dry an atmosphere, they circle around a mule or a horse very much like so many small bees; if hungry, however, they lose no time whatever, but with a few nervous jerks settle upon the selected spots and immediately go to work. They are never quiet, but are most active during early morning and towards evening. They also fly during moonlight nights. During the hottest portions of the day, from 11 a. m. to 4 p. m., they are more or less inactive. Their favorite time of attack is a cloudy, dark day, or when rain is threatening. If the gnats try to enter houses or stables by means of the windows, they constantly butt their heads against the panes of glass, until they become so exhausted that they drop to the ground and die. Specimens kept in confinement in large vessels, with the bottoms covered with moss and soil and containing a wet sponge and a saucer filled with water, die within forty hours. During all this time they never cease trying to escape. The sense of smell (and sight) of these insects must be well developed, because they unerringly find animals a long distance away from their breeding-places. If very numerous, they cover the whole animal, without making any selection of position.

The smaller Turkey Gnats are not so blood-thirsty, nor do they form such large swarms. The snorting, biting, switching of tails, and the general restlessness of the stock in the fields soon reveal the presence of their foes. The gnats will, upon arrival, rapidly circle around the animal, select a point of attack, fasten themselves upon the chosen spot, and immediately commence to bite. The genital and anal regions, the ears and portions of body between the forelegs—in short, those parts where the skin is most easily punctured—are selected by these insects. The attack is so rapid, that in course of one minute the body of the tormentor is seen to expand with blood, which shows plainly through the epidermis of the abdomen. The bitten part of the animal shows a nipplelike projection, and if the insect is removed by force a drop of blood as large as a good-sized pin's head will ooze out. Other gnats will almost at once pounce upon the same spot and continue the biting. All those veins which project under the skin of the animal are also favorable points of attack, and their course is made visible by the hordes of gnats fastened upon them.

The great danger of an attack by these insects lies in the unexpectedness of their appearance. As already mentioned there may be no indication of their presence in any neighborhood and the roads are free of them. But with the change of the prevailing wind they may appear, and when one is passing certain localities, such as low, wet, and shady ground, or dense thickets of underbrush, they will start forth like a cloud, and cover the animals at once. Open fields may be entirely free from gnats, but if animals pass certain places in them out dart the tormentors, and the animals attacked can only save themselves by running to high places exposed to the full rays of the sun. The gnats, following the animals for some distance, leave as suddenly as they appeared, and hide themselves again in the thickets. In the cities they appear suddenly with certain winds, chiefly with those blowing from the south, southeast, and west, and usually disappear again with winds blowing from the opposite direction.

ANIMALS INJURED.

Domestic animals are attacked in the following order, varying somewhat in different localities, viz, mules, horses, cattle, sheep, setting turkeys and hens, hogs, dogs, and cats. The death-rate of mules is highest, both because they seem to be more susceptible to the bite, and because they are almost exclusively used in the Southern States for farm work. Horses also suffer greatly. Cattle, when weakened by winter exposure and by scarcity of food, succumb easily to the continued attacks of their winged foes. Hogs show at first the effects of the bite but very little; yet large numbers die soon after the attack, while others die about six weeks after the disappearance of the Buffalo Gnats; they usually perish from large ulcerating sores, which cause blood-poisoning. Many persons claim that the so-called *charbon* is produced by the bites of these gnats, a statement which is, of course, not borne out by facts. Sheep, although well protected by their wool, suffer greatly by bites upon the unprotected portions of their skins, and injure themselves still more by crowding too close to fires, which are built to produce protecting smoke. Many sheep crowd so close to the fire as to be burned to death. Setting turkeys and hens are frequently forced by the gnats to leave their nests. Young fowls are killed outright. The gnats, in attacking fowls of all kinds, force their way under the wings of their victims, where they cannot be dislodged. Dogs and cats are also greatly tormented, and will not remain outdoors during a Buffalo Gnat invasion if they can help it. Deer, forgetful of any other threatening danger, are tormented to such a degree as to lose all fear, and approach the smoldering fires; in their agony they sometimes allow people to rub the gnats from their bodies, and will, in their frantic endeavors for relief, even lie down in the glowing embers or hot ashes.

EFFECT OF THE BITES.

Animals bitten by many Buffalo Gnats show all the symptoms of colic, and many people believe that these bites bring on that disease. Mules especially are thus affected, yet large numbers of *post mortem* examinations made by Dr. Warren King, of Vicksburg, and others, failed to show any relationship between this disease and the bites, nor were any facts obtained which would justify the correctness of such a popular conclusion. Dr. King opines that the effects of these bites

on animals are much the same as that of the rattlesnake on the human system. This seems to be the generally accepted opinion among the more intelligent planters. The animal attacked becomes at first frantic, but within a very short time it ceases to show symptoms of pain, submits passively to the infliction, rolls over, and dies; sometimes all within the space of three or four hours. Even if bitten by a very great number of gnats death does not necessarily follow, and then it is not always suddenly fatal. Mules which at night do not appear to be seriously injured will often be found dead next morning.

Animals of various kinds become gradually accustomed to these bites, and during a long-continued invasion but few are killed towards the end of it. It is a prevailing notion that the bite of the gnats appearing first is the most poisonous. It would seem to be more probable, however, that the poison introduced into the systems of animals—unless sufficient to prove fatal—may to some extent serve as an antidote against that introduced later, and if this poison should remain in the system with any stability, such a fact would also account for native or acclimated stock being less susceptible to the poison from bites than that recently imported. There is no doubt that stock freshly imported from Kentucky to Tennessee and Mississippi is more apt to be killed than that raised in the infested portions of these States, and that, having withstood one invasion, a second one proves fatal but seldom. One reason why Buffalo Gnats appearing very early in the season are more dangerous may be found in the fact that the stock, weakened by exposure during the winter, have had as yet no chance to gain in strength by feeding upon the early vegetation, which it obtains previous to and during a later invasion. Consequently, the resisting power of animals is greater later in the season. Experience has also taught owners of stock how to protect the same, and in comparison with former gnat seasons fewer animals are killed of late. Prof. J. A. Schoenbauer, who wrote nearly one hundred years ago about the Kolumbacz Gnats of Hungary, witnessed the *post mortem* examination of a horse killed by these gnats. Upon dissection it was found that not only was the anus entirely filled with the flies, but also the genital orifices, the nasal passages, and the bronchial tube and its ramifications. A case of this kind must be very exceptional. No doubt gnats will sometimes enter these passages, but as a rule death is not occasioned in this manner. The loss of blood and the terrible irritation of the skin by so many poisonous bites are reasons sufficient to account for the reflex irritation of the nerves and blood poisoning.

HOW ANIMALS PROTECT THEMSELVES.

The different kinds of animals, knowing their tormenters by instinct or experience, have various methods of protecting themselves against their attacks. To run away is the first impulse of all; but it is of no avail, since their enemies are too swift to be outrun.

Horses and mules, if not harnessed or tied, become perfectly frantic, and rush away hither and thither, roll themselves upon the ground, dash off again wildly, and repeat these actions until they become entirely exhausted. If they succeed in reaching an elevated spot free from trees and accessible to the full rays of the sun, they escape further severe molestation.

Cattle act in a very similar way, but instead of searching for higher, sunny spots, they prefer to rush through dense thickets, such

as are formed by canes, and thus rid themselves of many tormentors, but all in vain. If creeks are near by, some find partial protection by immersing themselves in the water.

Hogs also run madly about. If mud is accessible, they do not fail to make good use of that material and wallow in it.

Sheep run about blindly, crying piteously all the time.

Dogs and cats are sensible enough to search for dark shelters in stables or remain in the house.

Poultry of various kinds seek relief by flying in high trees. They assist each other in picking off their tormentors, thus partly freeing themselves.

Deer try to find relief by running away from the gnats.

But all such methods avail but little without the assistance of man. Fires are started everywhere to produce a dense smoke. As soon as the tormented animals notice such smoke they all show their good sense by rushing to it, invariably selecting that side of the fire where the smoke is densest. Here they crowd together, and many are injured by too close proximity to the glowing embers. Nor can they be driven away by hunger; and only during a dark night, or in the brightest light of the midday sun, do some of them venture out in search of food.

PREVENTIVES.

Smudges have thus far proved the best method of protecting animals in the field against Buffalo Gnats. Thoughtful planters are in the habit of collecting and storing during the year all kinds of material that will produce a dense and stifling smoke; such materials are old leather, cast-off clothing, dried dung, &c. As soon as large swarms of gnats appear, and the stock is threatened by them, fires are started in different parts of the plantation, and are kept burning as long as the danger lasts. Anything that will produce smoke is thrown upon the smoldering logs, and the most offensive is considered the most useful. If the time for plowing has arrived, smudges are located in the fields in such a manner that the smoke is drifted by the wind over the teams at work. Such smoke-producing fires are also kept burning in the cities, and they are found in front of every livery and street-car stable, as well as of such stores as employ draft horses or mules. If these animals have to be upon the roads, they may usually be somewhat protected by tin pails in which some smudge is kept, and which are suspended from their necks and from the wagons.

Animals may also be protected with a layer of mud or a coat of sirup. It has been found that animals which have shed their rough winter coat of hair and have become smooth are not as much troubled as others still covered with long hairs. The gnats find it much more difficult to obtain a foothold upon a smooth skin, and the clipping of the hair in early spring is therefore advisable.

Buffalo Gnats have a great aversion to entering dark places, and stables thoroughly darkened are safe places for stock of all kinds in a gnat season. The odor of ammonia prevailing in such stables may also to some extent prevent the insects from entering. Planters with a small acreage, therefore, prefer to keep their horses and mules in the stable instead of working them in the field. For the same reason the owners of livery stables will not allow their animals to be taken outside the city limits if gnats are numerous enough to be dangerous.

But the great majority of planters cannot wait for the disappearance of the pest, and have to resort to other defensive means. Various external applications have been used to this effect: Decoctions of Alder leaves, Tobacco, Pennyroyal, and other herbs, have been tried with a view of preventing gnats from biting mules while at work; but all of them have proven ineffective. At a time when small swarms of Turkey Gnats were tormenting mules plowing in the field one side of the animal was moistened by Mr. Lugger with various insecticides, while the other side was not protected at all. By following the animal and watching the gnats it was soon observed that any offensive-smelling substance would drive the gnats from the protected side to the unprotected one. Kerosene emulsion, pyrethrum powder suspended in water, diluted carbon-bisulphide, and dissolved tobacco-soap were all used in turn, and all seemed to produce the same effect. Several times the whole animal was carefully sponged with the one or the other of the above substances. For a time the gnats would not settle upon the animal; but in the course of two hours the beneficial effect of these insecticides was gone, and the insects were no longer kept away.

Experience shows that the best preventive is grease of various kinds. The following kinds are the most important: Cotton-seed oil alone, or mixed with tar, fish oil, gnat oil; a combination of stinking oils alone, or mixed with tar or kerosene oil, crude coal oil, kerosene oil, kerosene oil mixed with axle-grease, and others. To be effective, the grease must be used at least twice during the day, because as soon as its offensive odor disappears it becomes inoperative. All such applications are of no advantage, however, on stock running at large. Gnat oil is very extensively used, but it is like the rest of the remedies—very apt to remove the hair.* In fact, all these different kinds of oil and grease are more or less injurious to the animals, because a continued coating with them weakens the system.

The employés of the Hudson's Bay Company protect themselves and their stock against the bites of the "Black Fly" by the use of oil of tar, and as long experience has shown it to be a simple and easily applied wash, we strongly recommend its use. A quantity of coal tar is placed in the bottom of a large shallow receptacle of some sort, and a small quantity of oil of tar, or oil of turpentine, or any similar material, is stirred in. The receptacle is then filled with water, which is left standing for several days until well impregnated with the odor. The animals to be protected are then washed with this water as often as seems to be necessary.

As long as stock in the infested region is suffered to run at large, and is neither provided with shelter nor food during the winter months, it will suffer severely from the gnats. Animals well cared for can stand the attacks of the gnats far better, and do not perish as readily. Ill-treated and unhealthy mules and those bruised and cut are the first to die, and the prevailing opinion of intelligent planters is to the effect that well-cared-for mules, if greased twice a day when working in the field, seldom die even when attacked.

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*According to Messrs. Fahlen & Kleinschmidt, chemists, of Memphis, Tenn., "Gnat oil is any kind of stinking oil; it should not contain drying oils, such as *Oleum lini* and *O. gossypii.*" They use fish oil, and to increase its perfume add *Ol. animale fœtidum*, 4 ounces to 10 gallons. But since fish oil costs 50 to 75 cents per gallon, some mix it with crude petroleum; this addition, however, has the tendency to kill the hair roots. *Ol. hedeomœ* (pennyroyal) is too costly, and therefore not frequently used. *Fish oil* and *Ol. animale fœtidum* have given the best satisfaction.

REMEDIES FOR THE BITES.

A number of remedies to counteract the poison of the Buffalo Gnats have been tried, but none of them have been sufficiently tested or have proved uniformly effective.

Dr. Warren King, of Vicksburg, Miss., recommends rubbing the affected animals thoroughly with water of ammonia, and administering internally a mixture of 40 to 50 grains of carbonate of ammonia to 1 pint of whisky, repeating the dose every three or four hours until relieved. He claims to have never lost an animal under this treatment, although they were sometimes apparently beyond recovery. This remedy is not generally known, but certainly contains sufficient merit to warrant a thorough and careful trial.

Some planters claim to have cured their stock simply by continued doses of whisky alone and by keeping the sick animal in cool and darkened stables.

Blood-letting is also recommended, both as a preventive and as a cure, but may be considered as of very doubtful utility, except in cases where heroic treatment is required. Mules badly injured and in a dying condition are bled until the blood, which at first is nearly black, appears of a natural color again.

Dying animals have frequently been saved by immersion in the cold water of running streams. Evidently all these remedies have a tendency to allay the fever produced by incipient blood-poisoning.

ATTACKING MAN.

A number of cases have from time to time been reported by various newspapers in the infested region of human beings being killed by these insects. Inquiry has sometimes failed to prove the truth of such reports; yet sufficient facts are on record to show that if the gnats attack a person suddenly in large swarms and find him unprepared or far away from any shelter they may cause death.

Dr. Bromby, in Madison Parish, La., had a case of death caused, he believes, by the gnats. A Mrs. Breeme, having lost, in the spring of 1883, 17 mules of her stock, was suddenly taken sick. She told the doctor that she had been bitten by mosquitoes. She died in great agony from blood-poisoning.

In 1884 several persons were killed by Buffalo Gnats. Mr. H. A. Winter, from near Helena, Ark., while on a hunting trip, was attacked by them one and a half miles from home, while passing some low ground. Running towards a house, he was seen to fall dead. All exposed parts of his body had turned black. Another man was killed near Wynne Station, Arkansas, on the Iron Mountain Railroad.

DAMAGE DONE IN VARIOUS YEARS.

The damage occasioned by Buffalo Gnats throughout the infested region cannot be estimated, owing to the fact that no statistics have ever been collected in a systematic manner. But the loss in certain localities has been immense, and greatest when the insects appeared in the very early spring. Of late years the losses have increased because the country has become more densely settled and not because the bite of the gnats has become more dangerous. The following statements are based on reports from reliable individuals and from records in local papers examined by Mr. Lugger:

As far as can be learned the damage in Louisiana was but slight prior to 1850; but many animals were killed in 1861, 1862, 1863, 1864, and 1866. In this latter year the parish of Tallulah, Louisiana, lost over 200 head of mules, and upwards of 400 mules and horses were killed within a few days in the parishes of Madison, Tensas, and Concordia, all in the same State. In other States they also did great damage. In 1868 many mules were killed in the low lands of Daviess County, Kentucky. Although frequently causing more or less trouble and loss, they did not appear again in such overwhelming numbers until 1872, 1873, 1874, 1881, 1882, 1884, 1885, and 1886. In 1872 it was reported that the loss of mules and horses in Crittenden County, Arkansas, exceeded the loss from all diseases. In 1873 they caused serious injury in many parishes of Louisiana. In 1874 the loss occasioned in one county in Southwest Tennessee was estimated at $500,000. The gnats have been especially injurious since the Mississippi floods of 1881 and 1882; in the latter year they were more destructive to stock than ever before, appearing in immense numbers in Eastern Kansas, Western Tennessee, and Western Mississippi, and the great destruction of cattle, horses, and mules caused by them added greatly to the distress of the inhabitants of those sections of the country caused by unprecedented floods. Many localities along the Mississippi River in Arkansas also suffered severely. In 1884 Buffalo Gnats appeared again in great numbers and were fully as destructive as in 1882. In Franklin Parish, Louisiana, within a week from their first appearance, they had caused the death of 300 head of stock. They were equally numerous throughout the whole region infested, and for the first time in the history of the pest they attacked horses and mules on the streets of the cities of Vicksburg and Memphis. No general outbreak took place in 1885; yet gnats appeared in sufficient numbers to kill quite a number of mules in various parishes of Louisiana, especially in Tensas and Franklin. Buffalo Gnats appeared again in immense numbers in 1886, and extended throughout the entire lower Mississippi Valley, and swarms were even observed and doing damage far away from the region usually invaded. They came very late in the season, and consequently animals were in better condition to withstand their attacks. The damage was great, however, in many localities where planters had not taken steps to protect their stock.

Besides the actual loss by death of their stock, planters lose much valuable time in preparing their fields for the crops. It so happens that the gnats appear at a time in which the ground becomes fit to be prepared for cotton, and as it is very important to give that plant as much time as possible to mature, every day is very valuable in early spring. Planters owning large estates have to use their mules for plowing, notwithstanding the gnats, while farmers on a small scale can keep their animals in the stable, thus protecting them.

POPULAR OPINIONS ABOUT THE EARLY STATES OF THE BUFFALO GNATS.

The early states of both Buffalo and Turkey Gnats were as a rule perfectly unknown to the inhabitants of the infested regions when our investigations began. Yet the great, and in some seasons absorbing, interest taken in them gave rise to many speculations as to their origin. Many theories had been advanced from time to time and were discussed in the newspapers, and no facts had been observed

to throw light upon the many mooted points yet obscure in the popular mind.

From the very fact that the region infested by these insects contains many swamps, it was claimed by many that the gnats originated in them and nowhere else. Others were convinced that low and moist soil would produce them, since it had been observed that such localities would harbor gnats in abundance, and that their swarms would rise from the grass if animals approached.

Even such absurd theories as that the Mississippi water coming in contact with decayed leaves and similar material would spontaneously create them were stoutly maintained by some, while others claimed that the gnats were produced out of mud without undergoing any transformation whatever. There exists also a prevalent opinion among the more intelligent that the eggs are deposited upon grass, weeds, &c., where they remain until the water of an overflow reaches and submerges them, when incubation takes place. In this manner eggs were supposed to remain sometimes for years, or until the necessary conditions for incubation arrived with the cold water of the Mississippi River.

Many larvæ, which are found in large numbers about decayed logs and under rotten leaves in the woods, have given rise to the belief that such were the young of their dreaded foe. The larvæ of a family of flies, the *Chironomidæ*, which occur in vast numbers in all the water of the infested region as well as elsewhere, look somewhat like those of the *Simulium*. Their general appearance and their actions are very similar, and consequently they have frequently been mistaken for the young of the real culprit, and, in fact, were at first mistaken by our agents. But the flies resulting from these larvæ are very different, looking very much like mosquitoes with feathered antennæ; they also swarm in very early spring, but are innocent of any harm to animals.

We reproduce at Plate IX, Fig. 1, a figure of a *Chironomus* larva which was found in the pods of *Utricularia* at Vineland, N. J., by Mrs. Mary Treat. The figure was made by us at Mrs. Treat's request, and was published as Fig. 9, of her article entitled "Is the Valve of *Utricularia* Sensitive?" in Harper's *New Monthly Magazine*, February, 1876, Vol. LII, pp. 382–387. We have also figured on the same plate, at Fig. 2, *a* and *b*, the pupa of the same species and the adult of *Chironomus plumosus*, a species common to both Europe and America, and which was collected in great numbers by Mr. W. H. Seaman at Chautauqua Lake, New York, August, 1886.

HABITS AND NATURAL HISTORY.

THE EGG.—The eggs of the different species of the genus *Simulium* occurring in the lower Mississippi Valley have not as yet been discovered,* but sufficient is known, from analogy with closely allied species in this country as well as in Europe, to indicate the localities in which to search for the eggs of one of the species, the smaller Turkey Gnat, which is so common in the vicinity of small and rapid streams. These creeks descend from an elevated region not inundated by the Mississippi River. They are, however, greatly affected by an over-

*While this report is going through the press, word reaches us at Los Angeles, Cal., from Mr. Webster, who was sent to Louisiana especially to look for them, that the eggs have been discovered by him.—C. V. R.

flow, since the back water arrests the downward current and eventually forces the water back, thus completely filling the creek-beds with turbid river water. In such creek-beds trees of various kinds abound, as well as great masses of dead and fallen timber, too heavy to be floated away. All such projecting points offer sufficient space for the fly to deposit eggs upon, and such places we intend to have closely investigated the coming spring at a time in which the water is highest and in a neighborhood where flies are known to breed.

As mentioned in our report for 1884, Dr. W. S. Barnard has described and figured in the *American Entomologist* (Vol. III, pp. 191–193, August, 1880) the eggs and early states of a species of *Simulium* common in the mountain streams in the vicinity of Ithaca, N. Y. These eggs (Plate VIII, Fig. 7) were found on the rocks on the banks a few inches above the surface of the water, and we give herewith a description of them as a means of facilitating the finding of those of the southern species here treated of. The eggs are deposited in a compact layer; their shape is long ovoid, but on account of their softness and close proximity to each other they become distorted and polyhedral; one end is frequently flattened or concave. Each egg measures 0.40^{mm} by 0.18^{mm}. In Hungary the eggs of the Columbacz Midge (*S. columbaczensis* Schönbauer) have also been studied by Edward Tomosvary, and the observations have been published since his death by Dr. Géza Horváth.* It seems that this species is, as far as its habits are concerned, more intimately related to our smaller species than the larger and more dangerous Buffalo Gnat. Its eggs, which are enveloped in a yellowish-white slime and deposited towards the end of May or beginning of June, are also deposited upon stones or grass over which the water flows and in the brooks of the more elevated regions. The female of that species is said to deposit on an average from 5,000 to 10,000 eggs, but no detailed description is given, while we have found only about 500 in the ovaries of our species.

But when and where does the larger and true Buffalo Gnat deposit its eggs? At present nothing is known about it. Messrs. Lugger and Webster left too soon to discover the eggs, because no gnats were expected so unprecedently late in the season; while Mr. Fillion did not reach the affected region until too late. At the time in which the Buffalo Gnat swarms all the low land is flooded and the water in the bayous has reached a depth of 20 and more feet above the usual summer depth of 2 to 5 feet. The water at such a time has spread over thousands of square miles, and only the taller trees are above it. Over such an extent of surface it would naturally be almost impossible to find these small eggs; but it is now known that the members composing the swarms of Buffalo Gnats are all females, which, led by a mad desire for blood, leave their breeding-places not to return again, but to perish in consequence of this appetite. To perpetuate the species, therefore, copulation of the sexes must take place almost immediately after acquiring wings, that is, at or near the places of their birth, which latter the males do not seem to leave at all. Eggs, no doubt, will be found at such places. If deposited anywhere else their chances of hatching, or rather the chances of the newly-born larvæ remaining in the water after the subsidence of the same, would be slight indeed.

It admits of but little doubt that the eggs will hatch very soon after being deposited, for it is not likely, as has been claimed by

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*A. Kolumbácsi légy, Dr. Horváth Géza, in Rovartani Lapok, I. Kotct, 10. fuzet, Budapest, 1884.

some, that the eggs will remain dormant for a whole year, or even two and more years, in the place where deposited, only to hatch when reached by another overflow. Such theories are not borne out by any observed facts, and they are, moreover, contrary to the usual habits of similar insects.

Since some of the breeding places of the two species of insects are now well known, the finding of the eggs will only be a question of time.

THE LARVA.—The peculiar aquatic larvæ of both the Buffalo and Turkey Gnats resemble those of the other known species, and their distinctive features will be shown in the closing descriptive portions of the paper. Generally speaking, they are less than half an inch in length, subcylindrical, attenuated in the middle, and enlarged toward both ends; the posterior third of the body is much stouter than the anterior third, and almost club-shaped. The color of the larva varies greatly, and is usually more or less like that of the substance upon which it is fastened; it is marked by two dirty, greenish-gray, irregular spots upon each joint, on a whitish and translucent ground. The head, which is almost square, is yellowish, marked with a few darker spots and lines, and with a pair of small, black, approximate spots on each side that look like eyes, but are not. Besides the usual mouth organs the head possesses two additional brown and fan-shaped bodies, which are usually spread out and kept in constant motion when catching food; they open and close like a fan, and if folded can be partially withdrawn into the mouth. The smooth body of the larva is composed of twelve joints or segments, five of which form the club-shaped anal portion of the body. On the under side of the thoracic portion there is a subconical, retractile process, crowned with a circular row of short and sharp bristles. The anal extremity consists also of a subcylindrical, truncated protuberance, which is crowned with rows of bristles similar to those of the thoracic proleg. The larva possesses no stigmata, but immediately below the anal protuberance, on the under side of the body, there are three short, cylindrical, soft, curved, and retractile tentacles, to which the large tracheæ lead, and which are probably the organs of respiration.

In some of the most mature larvæ two kidney-shaped black spots are visible just above the thoracic proleg, one on each side. If closely investigated with a good lens it is seen that the tufts of filaments serving the future pupa for respiration are already formed under the larval skin. All these filaments arise from the same spot and are branches of a single internal tube.

Habits of the Larvæ.—The larvæ of the different species of *Simulium* are so very uniform in their modes of life that the description of the habits of one will suffice for all.

The most essential condition for the well-being of these aquatic creatures is rapid motion of the water in which they live. Wherever water of such a description is found in the region infested by Buffalo and Turkey Gnats the one or the other species can be found.

The next important condition of a suitable breeding-place is the presence of some stationary material in the water upon which to fasten themselves.

Water in rapid motion is only found in certain well-defined places, either in streams coming from an elevated plateau or in streams meandering through a level country. In the former any sudden bend and any obstruction, no matter how small, will produce accelerated motion of the water; in the latter, sudden bends are the chief cause. In the

former, there are numerous places where larvæ can securely fasten themselves, because large numbers of sticks partly embedded in mud are not disturbed by the rising water. Against such immersed sticks, as well as against fence-rails, &c., which cross such streams, numerous dead leaves are lodged and anchored by the mud. All such obstructions, forming small whirlpools just below them, are places in which the larvæ of the Turkey Gnats are found. Larger submerged logs, wholly or partly submerged stumps, brush, bushes, or any other material of like nature in the larger creeks and bayous give the larvæ of the Buffalo Gnat suitable places to anchor to.

Upon such material they cluster together, and, fastened by the posterior protuberance to the leaf, they assume an erect position, or make their way upward or downward with a looping gait. Frequently attached by a minute thread, they sway with the ripples at or near the surface of the water, often as many as half a dozen being attached by a single thread. While these larvæ make their way up and down these submerged objects with perfect freedom they do not venture above the water, and when about to pupate select a situation well down toward the bottom of the stream.

The larvæ of the Turkey Gnat are more often found fastened to submerged dead leaves in the smaller and more shallow creeks or branches. These larvæ are evidently somewhat social in their habits, as they crowd together upon one leaf in numbers varying from ten to thirty, and, judging from their uniform size, they must be the offspring of the same parent. As the current away from obstructions caused by twigs and leaves, decreases in swiftness, so do the larvæ decrease in numbers, until only a few feet away but one or two can be found. When first found, in early March, they are quite small, but they grow rapidly during the latter part of March and early April. They are quite stationary when not disturbed. Besides being fastened to the leaf by the last posterior segment, they are also securely anchored by a very fine silken thread. When disturbed they loosen their hold at once and float downstream, suspended and retarded by this thread, which very rapidly increases in length while the larvæ are drifting with the current. While thus drifting they jerk about in a lively manner, searching for a new resting-place, and sink to the bottom quite gradually. Owing to their small size, and to the fact already stated, that their color is in harmony with their surroundings or with the leaf upon which they are fastened, these larvæ are difficult to detect in a depth of 3 to 4 inches. When removed and put in a glass vessel they soon settle against the sides of their prison, and can then be studied with a lens.

The larva can move about very rapidly in the manner of a spanworm, but with this difference, that it always remains anchored by means of a thread, which lengthens as the animal proceeds. Being very restless and active in such confinement, it will keep on looping for hours, at a rate of twenty to twenty-five loops per minute. It can move both forward and backward; the forward motion being produced by fastening the single thoracic leg to the side or bottom of the vessel, loosening the anal proleg, bringing it close to the former, and letting the latter go at almost the same moment; the backward motion being simply a reversal. In the course of six to eight hours the larva becomes weak and sickly; it will drop to the bottom of the vessel if disturbed, but will no longer try to escape. All the larvæ thus imprisoned, in repeated trials, died in the course of twenty-four hours. A colony of nearly full-grown larvæ, in a small creek, shared the

same fate when the overflow of the Mississippi River created a back flow and made the water in this creek stationary for some time.

All the creeks and branches in which such larvæ were found by Mr. Lugger descend in beds composed of clay. The Rocky Bottom Branch, a tributary to the Horn Lake Creek, Mississippi, has worn out a bed in a solid deposit of stratified ferruginous sandstone, intermixed with conglomerations of the same substance. The water, 6 to 8 inches deep in normal seasons, even during the summer months, runs over this stony bed in very rapid currents, forming everywhere little cascades, and no better breeding-places for the larvæ of any *Simulium* could be imagined. Yet none could be found, plainly indicating that the species under consideration must be able to fasten to submerged material to find a suitable home.

Food of the Larvæ.—The larvæ of the Southern Buffalo Gnat are carnivorous in their habits, although they do not, perhaps, reject floating particles of a vegetable origin. Their mouth is not adapted for biting off any pieces from a large or solid substance, but is constructed to catch and ingulf small objects. To obtain these the fan-like organs peculiar to these larvæ create currents of water directed towards the mouth. Any small and floating matter drifted by the current of water into the vicinity of these fans is attracted by the ciliary motions of the component rays of the same, and thus reaches the space embraced by them, and they, bending over the mouth, direct the further motions of the particles. If of the proper kind they are eaten, otherwise they are expelled by a sudden opening or parting of the fans. They do not feed, as has been claimed, upon plants which they are unable to bite off or chew, and which do not exist in the water at the time when the larvæ grow most rapidly. A searching investigation of the water in their breeding-places revealed the fact that it was swarming with animal life, and was filled with the larval forms of small crustaceans belonging to various families, but chiefly to those of Coptopods and Isopods. An abundant supply of food must also be found in the presence of immense numbers of fresh-water sponges, polyps, and animalcula. Larvæ of the Southern Buffalo Gnat kept in glass vessels were observed to swallow these minute crustaceans, and none of this food was seen to be expelled again. A number of square diatoms, jointed together in a chain, have also been observed in the intestines of these larvæ by the aid of the microscope. The presence of such quantities of animal food will also account for the observed fact that the larvæ grow so very rapidly during the early spring, since this is the time of the year in which most of the small fresh-water crustaceans spawn and produce living young, and food is, therefore, much more abundant at this season than at any other.

There may be, and very likely is, a connection between an overflow by the Mississippi River and the amount and kind of food produced by it. During the long-continued heat of summer nearly all the swamp-land, as well as the majority of the bayous, dry up, either partially or entirely, and water remains only in small pools, in springs, and in perennial creeks. The animal life in all these places becomes more and more concentrated, while they fairly swarm with small creatures of all kinds, and if the larvæ of the gnats could lead a roving kind of existence, or could thrive in warm water, there would be no lack of food for them at this season. As great numbers of small creatures found in the evaporating and fast-disappearing water possess the faculty of coming to life again even after having been

dried up for a long time, an inundation resurrects vast numbers of them, and brings them furthermore within reach of the larvæ. These, however, are not active during the heat of summer, and an inundation at that time will not affect them at all; but if it should take place early in spring, this additional source of food would soon mature vast numbers otherwise doomed to die.

PUPA AND COCOON.—As soon as the larvæ are fully grown they descend towards the bottom of the water to make their peculiar pouches, and many pupæ are found at a depth of 8 to 10 feet below the surface; others much higher up. But in shallow water they may be found clustered one above the other, just above the bottom of the stream, their instinct having evidently taught them to provide for a sudden fall in the water. Notwithstanding this, with the water falling in the bayous and larger creeks at the rate of 1 foot per day, many pupæ are left high and dry. Those of the Turkey Gnats, which are always found just above the bottom of the smaller perennial creeks, are not thus endangered by a low stage of the water, which rises and falls suddenly with every heavy rain, but remains of uniform depth at other times.

In one of the breeding-places of the Southern Buffalo Gnats, at the junction of Crop and Mill Bayous, in Tensas Parish, Louisiana, Mr. Fillion found immense numbers of the dry and empty pouches as late as June 10, 1886; they were attached to vines, trunks of living trees, and leaves retained by the vines. All these pouches were found near the highest point reached by the overflow, forming a zone or belt from 3 to 4 feet in width. On July 15, the current, very swift in June, had almost ceased to be noticeable, and the stream had decreased from a width of 45 feet to that of 20 feet; the Crop Bayou was partly dry, and no obstructions or vines of any kind reached the water, which flowed in clear dry banks. The belt of dry pouches was at the latter date high above the water, the lowest being found some 13 feet above it, while the highest reached to the mark left by the overflow.

The cocoon or pouch spun by these larvæ is conical, grayish or brownish, semi-transparent, and has its upper half squarely cut off; it is fastened to sticks, leaves, or logs. The larva in spinning does not leave its foothold, but running in the center of its work, uses its mouth to spin this snug little house. In it it changes to a pupa, which has its anterior end protruding above the upper rim. These pupæ are at first of a light brown color, afterwards changing to a pinkish cast, and, just previous to the hatching of the fly, to black. During the first of the coloration epochs they are attached to the vegetable substances upon which the pouch has been fastened by the thoracic filaments, by threads about the body, and by the anal extremity; but during the last two the pupæ hang by the short anal attachment alone to the threads at the bottom of the pouch, and rise more and more out of the pouch, until at last they swing about freely in the current, attached only by the drawn-out threads.

The pupa itself is distinguished from most other Dipterous pupæ by the presence of a tuft of respiratory filaments starting from each side of the thorax. These tufts, as already stated, foreshadowed by two dark spots upon the sides of the thoracic segments in the larva, are composed of a greater or less number of very slender filaments, varying in number in the different species of *Simulium*. Along the posterior margins of each of the third and fourth dorsal segments there are eight minute spines; the tip of the abdomen is also armed with two larger and bent spines or hooks, by which the pupa is secured to

the inside of the open pouch. Remaining but a very short time in the pupal state, prolonged or shortened by atmospheric influences, they give forth the winged insects. The length of the pupal state in the case of the Turkey Gnat averages five days. Both larval and pupal skins remain for some time in the empty pouch.

The perfect insects issue from their pupæ under water, and surrounded, according to some writers, by a bubble of air. The silky hairs of the fly, however, are protection enough to prevent it from drowning. The winged insect pops to the surface like a cork, runs a few inches over the water, and darts away with great swiftness.

THE IMAGO.—The perfect fly varies in length from 3^{mm} to 4.5^{mm}, the females being usually the larger; the Turkey Gnat is somewhat smaller. Both insects are, like all other species of *Simulium*, characterized by their peculiar short and thick shape. The head is bent under, and is nearly as wide as the very large and humped thorax. The thick antennæ are composed of twelve stout joints; the four-jointed palpi terminate in long and fine joints; the posterior shanks and the first joint of the hind tarsi are somewhat dilated. The free labrum is as sharp as a dagger, and the very prominent proboscis is well adapted for drawing blood. The insects possess no ocelli, but their eyes are large; in the male they join at the forehead, but in the female they are farther apart. The mouth organs of the male are also not so well developed as in the female, being soft and unable to draw blood. The bodies of these gnats are quite hard and can resist considerable pressure. The color of the Southern Buffalo Gnat is black, but covered with grayish-brown, short, and silken hairs, which are arranged upon the thorax in such a manner as to show three parallel longitudinal black stripes; the abdomen is more densely covered with similar hairs, and shows, furthermore, a dorsal broad, whitish stripe, which widens towards the posterior end. The legs are more reddish, but also covered with hairs of the same color as elsewhere; the balancers are yellowish-white and the wings ample. The general appearance of the Turkey Gnat is very similar, but it is lighter in color.

The gnats are exceedingly active, and endowed with very acute, senses, which enable them to find unerringly animals a long distance away. Only females seem to form these aggressive swarms, since not a single male has been found in the large numbers captured and investigated. The male stays near the place of its birth, and since females once gorged with blood do not and cannot return, copulation and the depositing of eggs must take place very soon after emerging from the water. These points have as yet to be investigated.

NUMBER OF BROODS.

All species of the genus *Simulium*, the life-histories of which have been studied, are single-brooded, and no doubt Buffalo and Turkey Gnats form no exception to that rule. Extending as they do over such a vast area, we should expect their swarms in some seasons to form and appear continuously for five or six weeks before the whole brood had matured and disappeared. No Buffalo Gnats have ever been found in the infested region during the summer, fall, or winter, even when inundations have occurred in these seasons, and there are no indications of a second or third brood in the same year.

ENEMIES OF THE BUFFALO GNAT.

The Buffalo Gnats in their winged form have but few enemies among birds, because they usually appear at a time in the early spring when but few of our insectivorous birds have returned from their southward migrations. Besides the Mocking-bird and the Winter Wren, birds which remain in the more southern portions of the infested regions, no other birds have been observed to catch and feed upon them. Hens and chickens eat large numbers of such gnats as have become helpless by being gorged with blood. A single premature Dragon-fly, or Mosquito Hawk, and a brightly colored Hawk-fly (*Asilidæ*) were observed by Mr. Lugger to catch them in the fields. But the larvæ of the gnats do not fare so well. Although somewhat protected by their color and position in the water, many are discovered by small fishes belonging to the family *Cyprinidæ*, which frequent even the smallest creeks, and greedily eat them; other fishes in the larger creeks will probably act in the same way. The carnivorous larvæ of Water-beetles, as well as other aquatic insects, no doubt find them as well suited to their taste. The pupæ escape detection much better, because they do not move, and are, as a rule, hidden by the fine floating mud of the water which partially covers them and their pouches.

No insect enemies of any of the *Simulium* larvæ have been heretofore observed either in this country or in Europe. It is therefore interesting to note that the larva of a species of the neuropterous genus *Hydropsyche*, has been found by Mr. Howard near Washington feeding upon the larvæ of a local species of *Simulium*. The facts were communicated by him to the Entomological Society of Washington at its September (1886) meeting, and we quote his account of his observations:

> In the month of August, on the larger stones in parts of Rock Creek, District of Columbia, where the current was swiftest, and particularly on such rocks as were tilted so as to bring a portion of the surface close to the surface of the water, were observed hundreds of peculiar funnel-shaped larval cases or webs (Plate IX, Fig 5) of a species of this interesting Trichopterous genus. The cases varied greatly in size. The mouth of the funnel in some instances was not more than 3^{mm} in diameter and in others reached fully 10^{mm}. The tube of the funnel was in every case bent nearly at right angles with the mouth, and the larva ensconced within it waited for its prey to be caught in the broadened mouth. It was noticed that the cases were preferably placed at the edge of slight depressions in the rocky surface, so that the tubular portion was protected from the full force of the current. The broad funnel-shaped expansion was woven in wide meshes with exceedingly strong silk, and was supported at the sides and top by bits of twigs and small portions of the stems of water plants. The central portion was so open as to allow the water to pass through readily. The tube was strong and tight and was covered with bits of leaves and twigs. It was open at either end. On the surface of a rock about 18 inches in diameter 166 of these nets were counted. At this portion of the stream the larvæ of a *Simulium* (probably *S. venustum*, Say) were very abundant. They occurred chiefly on the small water plants which grow in these rapid places, and were found in considerable numbers on the surface of the rocks on which the cases of *Hydropsyche* occurred. They must have been washed into the mouths of these nets in great numbers, and probably furnished the principal food of the carnivorous larvæ. The *Hydropsyche* larvæ (Plate IX, Fig. 3, and enlarged head, Fig. 4) were very active and difficult to capture, unless the stones were removed entire from the water. Placed in standing water they fought vigorously with each other, and after a lapse of twenty-four hours did not seem appreciably affected by the want of fresh water.

Miss Cora H. Clarke has described the nets of a similar species of *Hydropsyche* (Proc. Bost. Soc. Nat. Hist., vol. 22, May 24, 1882), but does not mention the insects which formed the food of the larvæ observed by her.

DESCRIPTIVE.

There are some characters which these two species possess in common with all other species of the genus, though scarcely any of the described species are known in both sexes. It may be well to state, therefore, that the male differs markedly from the female in his much smaller abdomen and relatively larger thorax, by the mouth parts being soft and subobsolete, and more particularly by the eyes being confluent and having two well-marked and distinct sets of facets. As we have already stated, the male is not found flying with the female, and we should not have obtained this sex in the two species here treated of had they not been bred from the larvæ. It is desirable to describe both sexes from fresh and living specimens, as they become sordid in alcohol, and shrink and lose much of their character and color when mounted dry. The females are also somewhat altered in appearance after having been gorged with blood. The prothoracic is the only spiracle traceable in the insects of this genus.

The larvæ of all the species known have very much the same general form and structure, and they differ chiefly in some of the details of the flabelliform fan and of the mouth parts.

The pupa in form foreshadows that of the future fly, and the species differ in this state chiefly in the number of filaments or ramifications thereof that compose the breathing organs. These are invariably situated, one on each side, upon the anterior dorsal margin of the thorax, each originating in a single trunk, which soon branches into rays which are fine hollow tubes, apparently composed of rings, and closed at their extremities. Each tube consists, further, of one or two chitinous layers covered by a finely granulated material. In both the species under consideration there are two of these chitinous layers, of which the inner is very thin and smooth, the outer thicker and furnished with pores. The base of the trunk connects by a stigma-like ring with a true spiral tracheal tube visible beneath the epidermis, and which, bending suddenly inwards, contracts and connects with the internal tracheal system of the corresponding side.* At the tip of the last abdominal segment, upon the dorsal surface, are two hooks, which engage in the meshes of the cocoon, to hold the pupa in position. Some few threads of loose silk and the old larval skin are also found in this situation. Minute black hooks, arranged in regular and definite order upon the dorsal and ventral surface of the abdomen, assist the pupa to keep its position inside the open cocoon. These hooks are usually bent upwards.

The cocoons of the various species differ from each other both by their structure and by the method by which they are fastened to plants, stones, &c. Generally speaking, the cocoon is a brownish, obconical, semi-transparent pouch, open above, more or less covered with mud, and directed against the current of the water. The pupa is more or less tightly surrounded by it, and has the anterior portion protruding above the rim of the pouch. The cocoons are formed of irregular threads, which harden rapidly in the water, and in the deeper parts of the cocoons there are also some long loose and disconnected threads.

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* Dr. Vogel, in his description of the tracheal tubes of the pupae of *Simulium*, gives a similar description, stating that, contrary to the published opinion of Siebold, there are no tracheæ inside the tubes.—Mittheilungen der Schweizerischen Ent. Ges., Vol. VII, Heft 7.

SIMULIUM PECUARUM, n. sp.—♀. (Plate VIII, Fig. 3, and dorsal view, Fig. 5). Length, 2.5 mm to 4 mm. *Head* (Plate VIII, Fig. 2), uniform grayish-slate, clothed with short yellowish hair, which becomes longer behind the eyes; eyes black, with coppery or brassy reflections; *antennæ* black, with whitish pubescence, and with a few bristles on two basal joints, which are tinged with red; joints 1 to 11 gradually diminishing in thickness towards the last, joint 1 shortest, joints 2 and 3 twice as long as joint 1, joints 4, 5, and 6 as long as joint 1, joints 7, 8, 9, and 10 gradually increasing in length, last joint fusiform, twice as long as joint 10; maxillary palpi a little longer than antennæ, blackish, with long grayish bristles. *Thorax* grayish-slate, more or less densely covered with short yellow hairs, and with usually very distinct markings, consisting of two mediodorsal and two subdorsal, broad, longitudinal, sooty-black bands, of which the latter curve to posterior edge of patagium, which is reddish at tip; lateral edges of prothorax with fine black sutures; under side of thorax uniform grayish-slate, with sparse yellow hairs; space around the one large stigma lighter; halteres opaque, reddish-white; legs uniform reddish-brown, densely covered with yellowish hairs; tips of tarsi blackish: wings subhyaline; larger veins and base reddish-brown. *Abdomen* nine-jointed; joints subequal in length, except the last 2, which decrease in length; a longitudinal, broad bluish-gray dorsal band extends from near base of segment 2, where it is broadest, to the tip, curving downward to the anterior lateral edge of segment 7; below this band laterally the color is blackish-brown, with the exception of a broad bluish-gray transverse band on the posterior edge of each of segments 1 to 6; under side of abdomen uniform brownish-gray, without markings; abdomen densely covered with yellowish hair, which is very long upon the posterior edge of segment 1, forming an overlapping fringe.

♂.—Length varying from 1.5mm to 2.2mm. Differs considerably from female. *Head* (Plate VIII, Fig. 1,) not visible from above, being occupied by the very large confluent eyes; the remaining parts below the eyes are black, with black hairs and bristles; eyes composed of two different kinds of facets, those above being very large, as large again as those of the female, and those in front and surrounding the dwarfed trophi very minute, the dividing line between the two sizes being abrupt [the figure is not accurate]; antennæ similar to those of female, more pronounced in color, both the black and reddish being more vivid; maxillary palpi black, and shorter than the antennæ. *Thorax* black above, with sparse yellow hairs; legs somewhat lighter in color, tips of tarsi not black; hairs upon legs longer than in those of female. *Wings* hyaline, veins and base yellowish-brown. *Abdomen* black, with grayish-white posterior margins to segments, dorsally and laterally, and covered with longer yellowish hairs.

Described from two bred specimens.

Larva (Plate VI, Fig. 1 and Fig. 2, showing head in three positions).—Average length when full grown, 7mm to 8mm. Subcylindrical, the club-shaped posterior third of body being twice as stout as the thoracic joints, and joint 4 the most constricted. Translucent when living, dirty white in alcohol; immaculate in a very few specimens; distinctly marked in the great majority with brownish dorsal cross-bands in middle of joints, leaving free a white mediodorsal longitudinal line; thoracic joints with three irregular rings of the same color; under side more or less irregularly spotted with brown. *Head* subquadrate, horny, yellowish-brown, with a number of brown spots and lines in regular order (as in figure) and two roundish approximate ocellate black dots on each side under the skin, and seemingly rudimentary organs of sight, from which the future compound eyes originate: *antennæ* (Plate VI, Fig. 5 *a*) uniformly pale, three-jointed, about one-third as long as greatest width of head; joint 1 very stout, fully four times as thick as 2, which is a little longer than 1, straight, slightly tapering towards tip; joint 3 extremely small, a mere triangular tip: *mentum* (Plate VI, Fig. 3 *a*) subtriangular, with apex cut away and replaced by three groups of very small teeth, of which the central group consists of three teeth, the middle one largest, and the groups on side, of four teeth, of which the second from center is largest; sides of mentum, near apex, with two small teeth each; all the teeth are chitinous and black; a long erect bristle, pointing upward and inward, near each side of mentum: *labrum* (Plate VI, Fig. 3 *b*) horny, densely covered with hair: *mandibles* (Plate VI, Fig. 5 *b* and *c*) resembling in shape the profile of the inverted last joint of the human thumb, with a series of teeth in place of the nail; teeth difficult to see, owing to the presence of five distinct brushes of hair; upon extreme lower tip of mandibles three large teeth, below them a series of eleven slender and very pointed teeth, of which the first two are the smallest, teeth 3 to 9 increasing and teeth 10 and 11 gradually decreasing in length; a second series of teeth below them consists of two triangular teeth, of which the first is largest: *maxilla* (Plate VI, Fig. 6) stout, fleshy, with an internal thumb-shaped lobe; *maxillary palpus* two-jointed, first joint cylindrical, second very short, crowned with a regular circular

row of short spines or warts: *labium* (Plate VI, Fig. 3 *c*) horny, with two brushes of hair above, between which is a very small *ligula* covered with a small brush of hairs; *fans* (Plate VII, Fig. 1) composed of a stout stem, bearing about forty-six scythe-shaped rays, lined on the inside by very minute, equidistant, erect hairs of equal length. *Thoracic proleg* (Plate VI, Fig. 4) faintly four-jointed, subconical, retractile (introversible), very thin and transparent, crowned with about twenty rows of short, sharp hooks, apparently arranged in a circular manner; the hooks, of which ten are in each row, seem to be movable to a certain extent, and are fastened or hinged to small chitinous rods in the epidermis. *Tip of abdomen* (Plate VI, Fig. 7) formed by a subcylindrical body, crowned with rows of hooks. *Breathing organs* below these hooks and on the upper side of abdomen; they consist of three short, cylindrical, soft and retractile tentacles, which connect with the large internal tracheæ (Plate VI, Fig. 7).

In full-grown larvæ a spot more or less dark (as in our figure) is seen on each side of thoracic joint; it is produced by the formation of the coiled breathing tubes of the future pupa.

Pupa.—Average length, 5^{mm}. General color, when fresh, honey yellow; prothoracic filaments brown, and the abdomen dorsally also tinged with brown, except a mediodorsal space; all the members have also a fine brown marginal line. Prothoracic filaments consisting of six main rays issuing from the basal prominence and subdivided two or three times, so that in most cases as many as forty-eight terminal filaments can be counted. Abdominal joints 3, 4, and 5, each with eight well-separated dark-brown and anteriorly-recurved hooks (Plate VI, Fig. 8), the four on each side separated by a mediodorsal space; those on joint 3 less conspicuous than those on joints 4 and 5; joint 6 without armature; joints 7, 8, 9, and also subjoint less distinctly armed near anterior margin with a continuous dorsal row of very minute posteriorly recurved points; ventrally joints 6, 7, and 8 have each four very minute anteriorly recurved hooks.

Cocoon.—Average length, 3.5^{mm}. Not completely made and not entirely covering the pupa, but tightly surrounding its larger portion. Shape very irregular, with no distinct rim at the upper edge, which is more or less ragged. The threads composing it are very coarse, and the meshes rather open and ordinarily filled with mud. Not always fastened separately to objects, but frequently crowded together, without forming, however, such coral-like aggregations as in some of the Northern species.

SIMULIUM MERIDIONALE, n. sp.—♀. Length, 2.5^{mm} to 3^{mm}. (Plate VIII, Fig. 6.) *Head* uniform slate-blue, verging to greenish or cerulean blue in some lights, clothed with silvery pubescence, which becomes longer behind the eyes; parts below antennæ and trophi more densely pubescent, producing the effect of a white face; eyes with a metallic, coppery luster: antennæ black, with very dense white pubescence; no bristles on basal two joints, which are but very slightly tinged with red; joint 1 shortest; joints 2, 3, and 11 subequal in length; joint 3 widest; joints 4 to 9 subequal in length; joint 10 but slightly shorter than joint 11, which is fusiform; joints 3 to 11 gradually decreasing in width; maxillary palpi as long as antennæ, blackish, with long whitish bristles. *Thorax* slate-blue, with less dense silvery-white pubescence; markings quite distinct, producing the effect of a sculpture, and consisting of three black longitudinal lines, the median narrow, widening a little at apex, and the outer ones curving inwards at base and outwards near apex, sometimes reaching to base of patagium, which appears whitish on account of dense pubescence; on the lateral edges of prothorax are fine black sutures; under side uniform slate-blue, with sparse pubescence; space around the large stigma almost white: halteres white, very faintly tinged with red. *Abdomen* nine-jointed, joints subequal in length, except the last two, which decrease; markings entirely different from those of *S. pecuarum*, formed by velvety black, dark blue and bluish-white, almost silvery, colors; the dark blue appears upon dorsal surface of the last five segments, spreading from a roundish median spot on 5 to the immaculate blue of the last two segments; segments 2, 3, and 4 have each a black cross-bar, and 5, 6, and 7 two narrow black submedian stripes, which disappear almost entirely upon 7; the bluish-white forms an outer edge to all the black and extends over the whole lower surface of abdomen, with the exception of more or less well-marked black cross-lines in middle of each segment; a bluish-white or silvery pubescence covers the entire abdomen, but is very sparse upon the dorsal parts. *Legs* brownish-black; tarsi almost black, and more or less densely covered with whitish hairs. *Wings* subhyaline, veins bluish-white, base ferruginous.

Described from many bred and captured specimens.

♂.—(Plate VIII, Fig. 4.) Length 1.5^{mm} to 2^{mm}. Very different in appearance from female. *Eyes* confluent, very large, brilliant coppery; a very marked difference in the size of the facets, those on upper surface being very large and metallic-coppery, those below and surrounding trophi becoming suddenly small, black, with bronze

reflections; *trophi* reddish-black, dwarfed; *antennæ* black, with light yellowish-brown pubescence in front. *Thorax* above intense black, velvety, with a bluish luster; under side grayish. *Legs* reddish, with black tarsi; *wings* hyaline, veins and base bluish-white. *Abdomen* above black, with posterior margins of segments edged with gray; under side of segments 2 and 3 light reddish-gray, the others blackish with gray posterior margins. Sexual organs black. Thorax and abdomen very sparsely clothed with white pubescence.

Described from three bred specimens.

Larva.—(Plate VII, Fig. 2.) Length when full-grown 5.5^{mm} to 7^{mm}. Normal shape and general appearance. Differs from *S. pecuarum* by the much more irregular markings of segments and head. A majority of the larvæ possess one or two lateral spots on club-shaped posterior third of body. *Head* lacks the regular arrangement of spots and lines, which become confused; the two black spots on each side present. *Antennæ* (Plate VII, Fig. 3*a*) uniformly pale, much longer than in *pecuarum*, slender and 3-jointed; first joint almost twice as long as joints 2 and 3 together, and a little bent; at base three times and at tip twice as thick as second joint, which is nearly uniform in width, tapering but very slightly towards tip; joint 3 small and pointed, about one-fifth as long as joint 2. *Mentum* (Plate VII, Fig. 4) similar to that of *S. pecuarum*, but distinguished by a flatter apex, by the possession of three erect bristles on each side, starting from round pores, which decrease in size towards base; a fourth very small bristle close to base and in line with the bristles above; the sides of mentum have on each side four sharp teeth. *Labrum* and *labium* not different from those of *pecuarum*. *Mandibles* (Plate VII, Fig. 3*b* and 3*c*) possess but seven teeth in first row; the three first nearly uniform in length; teeth 4 to 7 gradually decrease in length; tooth 4 much the longest of all; the two teeth in second row similar to those of *pecuarum*. *Maxillæ* and *maxillary palpus* also similar. *Fans* similar, but the hairs lining the inside of the scythe-shaped rays are thicker and nearer together. *Proleg* more slender; last joint bearing a crown of hooks, usually bent suddenly toward head. Tip of abdomen similar to that of *pecuarum*. *Breathing organs* (Plate VII, Fig. 5) quite different; the three main trunks branch each six times, and the branches enter the trunk from both sides. Full-grown larvæ show also the newly formed coiled breathing tubes of the pupæ through their skin.

Described from many specimens.

Pupa.—(Plate VII, Fig. 6.) Average length, 3.5^{mm}. Shape and coloration as in *S. pecuarum*. The thoracic filaments consist only of the six original rays, which do not branch. Upon dorsal surface of the posterior margins of abdominal joints 4 and 5 is a row of eight anteriorly curved hooks similar to those of *pecuarum*, but none on joint 3; anterior margins of joint 9 and of subjoint with a continuous row of smaller anteriorly curved hooks; joints 7 and 8 unarmed dorsally; ventrally joints 6, 7, and 8 have each four minor hooks.

Cocoon.—(Plate VII, Fig. 6.) Length, 3.5^{mm}. Neater than that of any other species known to me, being formed of fine threads, lined with gelatinous ones. The web is quite dense, uniform, with well-defined, sometimes thickened rims. The cocoon is always securely fastened singly to leaf or stick, and even if many are fastened upon the same leaf they do not crowd each other. It fits snugly about the pupa, which is so securely anchored inside as to be with difficulty extricated.

REMEDIES TRIED AND PROPOSED AGAINST THE LARVÆ.

The results of a number of different experiments with insecticides upon the larvæ of the Buffalo Gnats made by Mr. Lugger during the early spring indicates that it is nearly if not quite impossible to reduce their numbers by killing them in the streams. To attempt to do so when all these streams are swollen, and frequently from 10 to 20 yards wide and half as deep, would be sheer waste of time. When the water is very low and much more sluggish in its motion, thus bringing the chemicals in contact with the larvæ, an application of them might be more effective. Great caution must be used in any efforts in this direction, however, as both man and beast are in many localities entirely dependent upon these streams for their water supply and the introduction of poisonous substances might cause much trouble.

Some of the experiments were made by confining the larvæ in glass tubes and submitting them to a current of water to which the following decoctions and solutions had been added, viz: China berries, salt, lime, sulphur, tar water, kerosene emulsion, and carbon-bisul-

phide. Strong tar water killed them; diluted it proved harmless. Kerosene emulsion diluted to contain 5 per cent. kerosene was effective; three ounces of carbon-bisulphide in 7 quarts of water proved fatal within ten minutes; the other insecticides were ineffective. It would be very costly to put enough of these materials in the water to produce the desired effect.

Other experiments in smaller creeks, in which numerous larvæ of the Turkey Gnat were observed, were carried out in a different way. The materials tried were freshly burned lime, emulsion of kerosene, powdered pyrethrum, carbon-bisulphide, powdered cocculus indicus, and tobacco soap. With the exception of the lime, which was thrown into the water in pieces of the size of an Irish potato, all the others were in a watery solution or suspension. Repeated trials with all the chemicals produced the same effect. As soon as the larvæ came in contact with any of the insecticides they would immediately loosen their hold upon the leaf and drop down-stream. When the insecticides became so much diluted as not to incommode the larvæ any longer, these would again fasten to leaves. By using a larger amount of the various substances many larvæ were killed, as well as most of the small fish and aquatic insects.

But if the breeding-places in the creeks have to be searched out to apply the insecticides, it would be much more simple to remove all the logs, sticks, and leaves. All the fences across the branches should be removed, or rather should be replaced by wire fences, which would neither impede the current nor catch as many sticks and leaves. Logs and larger twigs, if not embedded too deep in the mud of the creek bed or banks, will always be removed by any high water; a very common occurrence in the Buffalo Gnat region. Old leaves, made heavy by the adhering mud, would also be carried away by any high water if the obstructions in these creeks were removed, and with these sticks and leaves many if not most of the larvæ would be carried away either into the main rivers or the lower level of the creeks or lakes, where there is no current and where they would soon perish.

If the general opinion that broken levees are to blame for the destructive swarms of Buffalo Gnats prove to be the correct one, the restoration of such levees would, within a few years at most, restore the former immunity from these insects. This time would be materially hastened by the removal of obstructions in all such parts of the bayous where they would come in contact with the swiftest current.

OVERFLOWS AND BUFFALO GNATS.

It is very generally claimed by the inhabitants of the infested region that as long as the States bordering upon the Mississippi River had a perfect levee system, which prevented the water from escaping into the inland bayous, no damage was occasioned by Buffalo Gnats, not even in districts now badly infested. It is further claimed that the Buffalo Gnats appear with every overflow, and only with an overflow if such overflow occur at the proper season and with the proper temperature, viz, during the first continuous warm days of March, April, or May.

The chronological data already given seem to prove such assertions correct. Too much weight should not, however, be attached to these data. The region is as yet rather thinly settled, and no systematic records of the appearance of Buffalo Gnats in injurious numbers have ever been kept. A general and widespread appearance of these

insects seems to take place, however, only during an inundation, and, granting the connection between the two phenomena, the causes for it are yet obscure. It was by the elucidation of this problem that we hoped to discover some means of preventing the injury of the flies by preventing the multiplication of the larvæ.

Inundations in the lower Mississippi Valley are not occasioned by local rains, but by the immense volume of water brought down by the river and its more northern tributaries, and such overflows first take place in the northern regions infested by the Buffalo Gnats, and not in the southern. The earlier appearance of these insects in the South would seem to invalidate the prevailing belief that an overflow brings them. Similar conditions prevail in Hungary, where a closely allied insect does so much injury to all kinds of live stock. There the gnats appear every spring in varying numbers, forming local swarms which move about with the wind: but no general invasion takes place until the river Danube inundates the region infested.

Is it not probable that swarms of these gnats are forced by the conditions consequent upon an inundation to extend their flight beyond their usual haunts to the more elevated and drier regions, and that in this fact we have at least one of the causes of the connection? Small swarms, otherwise local and unobserved, would thus, during a period of high water, be forced to band together in such immense armies. There must be other reasons, not yet clearly demonstrated, why these insects appear in such vast swarms with an overflow, and this problem can only be solved by a critical study of many breeding-places during several seasons over the whole region involved.

Some peculiarities of the swarms of Buffalo Gnats have been observed, and these may, by closer study in future, throw some light upon the problem. It is to be noted that all the specimens composing these swarms are females, and that not one male has been found among them either here or in Europe. There is every reason to believe that none of the females composing the blood-thirsty swarms return to the localities where they were born and developed. Experience indicates that once gorged with blood they die. The swarms dwindle in proportion as they are carried away or move from their breeding-places.

Close investigation with the microscope has failed to reveal any eggs in the ovaries of the females composing these swarms, and if they deposit eggs at all it is before congregating to attack animals.

These singular facts invite speculation and theory, but it were unwise to indulge in these before we have learned more about the eggs, when and where deposited, and whether the females depositing them are in any way different from those comprising the swarms. Dr. Fritz Müller has published in the *Archivos do Museu Nacional do Rio de Janeiro*, Vol. IV, p. 47, pl. IV–VII,* some very interesting observations on another fly (*Paltosoma torrentium*), the larva of which is only found in the torrents and cascades of certain streams descending the mountains of Brazil. There the pupæ fastened by the flat venter to the rocks under water, and change into the perfect flies. He found by opening the mature pupæ that there are always two forms of females associated with one form of male. The one form of female possesses a rudimentary mouth, only fit to sip

* Reviews of his paper appeared in *Kosmos*, Vol. VIII, pp. 37–42; *Nature*, July 7, 1881, p. 214; *Entomologist's Monthly Magazine*, February, 1881, p. 206 and pp. 130–132, and March, 1881, pp. 225, 226.

honey while the other has a mouth well adapted to penetrate, the skin of warm-blooded animals and to suck blood.

The male *Simulium*, so far as known, is only found near where it developed. The structure of its mouth prevents it from biting, and it shows no inclination to join the roving swarms of females. Hence pairing of the sexes must take place in the vicinity of birth, and the eggs are probably deposited soon afterwards. It is also possible, as in the case of other Diptera, that the eggs are already well developed in the pupa.

The condition of the inundated region forbids an indiscriminate selection of places to deposit in, since the young larvæ must in time find suitable swift currents of water after the subsidence to the normal level. Such breeding-places we hope to be able to map out in future.

It has also been claimed that a number of successive broods of the Buffalo Gnat appear in early spring. If such were the case the relationship between the presence of the gnats and an overflow could be very readily imagined; but we have already shown that there is absolutely no proof thus far of more than one annual brood.

Mr. Webster, while studying in the neighborhood of Vicksburg last spring, was impressed with the idea that the connection between the *Simulium* increase and overflows was dependent upon the condition of the levees, in that the river water in swelling the waters of the bayous not only creates a stronger current in the main bayou, but brings the current in contact with many trees and shrubs, as well as stumps and vines, along the bayous, thereby offering much greater chance for the larvæ to attach themselves.

While we were at first inclined to give some weight to this view, and it seemed to afford an additional important argument in favor of keeping the levees in good condition, a survey of the whole field leads us to abandon this as the most important cause in the increase of the gnats during the period of the overflow, and to adopt the theory already advanced, viz, that the connection is at least partly due to the gnats being driven by the advancing waters from the lower to the higher lands.

Another theory, not supplanting this last but supplementing it, we would advance here: There is no doubt but that the advance of the waters from the main river and their commingling with the clearer streams and tributaries carry a suddenly increased food-supply, in the way of minute crustacea and other aquatic creatures, to the *Simulium* larvæ just at the season when these are about to transform. It is quite probable that development in these larvæ remains more or less latent or stationary during the cold winter months or when the water in which they occur is depleted of minute animal life, and that a sudden access of food would accelerate the final transformations.

A possible third connection between the overflow and this increase may arise from the fact that the larvæ, when the water rises, leave their attachments, or that the débris upon which they are fastened becomes itself started by the flood current, and that in consequence the larvæ from hundreds of smaller streams and tributaries are carried away by the rising water and impelled into the current of the large streams, by which they may be carried for many miles, spreading out at last in the overflowed region at just the time when they are ready for their final transformations. On this theory the larvæ from regions far distant become massed in the overflowed region and vastly augment the numbers which have naturally bred there.

THE FALL WEB-WORM.

(*Hyphantria cunea*, Drury.)*

Order LEPIDOPTERA; family BOMBYCIDÆ.

[Plates X and XI.]

This insect has from time to time attracted general attention by its great injuries to both fruit and shade trees. Many authors have written about it, and consequently it has received quite a number of different names. The popular name "Fall Web-worm," first given to it by Harris, in his "Insects injurious to Vegetation," is sufficiently appropriate as indicating the season when the webs are most numerous. The term is, however, most expressive for the New England and other Northern States, where the insect is single-brooded, appearing there during August and September, while in more southern regions it is double-brooded. In our third Missouri report we first called attention to its double-broodedness at Saint Louis, and we find that it is invariably two-brooded at Baltimore and Washington. Except in seasons of extreme increase, however, the first brood does no wide-spread damage, while the Fall brood nearly always attracts attention.

We have decided to call attention to this insect somewhat in detail in this report because of its exceptional prevalence and injury in the Atlantic States during the year 1886, and because it became a public nuisance in the city of Washington, and the District Commissioners have formally requested information from us on the subject.

NATURAL HISTORY.

LIMITATION OF BROODS.—At Washington we may say in general that the first brood appears soon after the leaves have fully developed, and numerous webs can be found about the first of June, while the second brood appears from the middle of July on through August and September. In Massachusetts and other Northern States the first moths issue in June and July; the caterpillars hatch from the last of June until the middle of August, reach full growth and wander about seeking places for transformation from the end of August to the end of September.

The species invariably hibernates in the chrysalis state within its cocoon, and the issuing of the first brood of moths is, as a consequence, tolerably regular as to time, *i. e.*, they will be found issuing and flying slowly about during the evening, and more particularly

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*We have adopted the name *Hyphantria cunea*, following Clemens's reasons for separating *Hyphantria* from *Spilosoma*. He shows (Proc. Ac. Nat. Sci. Phil., 1860, p. 530) that, while agreeing in the wings, *Hyphantria* differs in the labial palpi, the second joint of which is very short and the terminal joint nearly rudimentary, and in the hind tibiæ, which have but one pair of small apical spurs.

The following is the synonymy of the species:

Phalæna (*Bombyx*) *cunea* Drury, 1782.
Phalæna punctatissima Abbott and Smith, 1797.
Cycnia cunea Huebner, 1821.
Spilosoma cunea (Drury), Westwood's Ed. Drury, 1837.
Hyphantria textor Harris, 1841.
Euproctis textor (Harris); Walker, 1855.
Hyphantria punctata Fitch, 1856.
Hyphantria textor Harris, Clemens, 1861.
Spilosoma cunea Drury, Brooklyn Soc. Check-list of Macro-Lep., 1882.
Hyphantria cunea (Drury), Grote's Check-list, 1882.

at night, during the whole month of May, the bulk of them early or late in the month, according as the season may be early or late. They couple and oviposit very soon after issuing, and in ordinary seasons we may safely count on the bulk of the eggs being laid by the end of May. During the month of June the moths become scarcer, and the bulk of them have perished by the middle of that month, while the webs of the caterpillars become more and more conspicuous. The second brood of moths begins to appear in July, and its occurrence extends over a longer period than is the case with the first or spring brood. The second brood of caterpillars may be found from the end of July to the end of September, hatching most extensively, however, about the first of August.

In Massachusetts and other Northern States the first moths issue in June and July; the caterpillars hatch from the last of June until the middle of August, reach full growth, and wander about seeking places for transformation from the end of August to the end of September.

The following general remarks upon the different stages refer to Washington and localities where the same conditions hold.

THE EGGS (Plate X, Fig. 3*a*).—The female moth deposits her eggs in a cluster on a leaf, sometimes upon the upper and sometimes on the lower side, usually near the end of a branch. Each cluster consists of a great many eggs, which are deposited close together and sparsely interspersed with hair-like scales. In three instances those deposited by a single female were counted. The result was 394, 427, and 502, or an average of 441 eggs. But in addition to such large clusters each female will deposit eggs in smaller and less regular patches, so that at least 500 eggs may be considered as the real number produced by a single individual. The egg, measuring 0.4^{mm}, is of a bright golden-yellow color, quite globular, and ornamented by numerous regular pits, which give it under a magnifying lens the appearance of a beautiful golden thimble. As the eggs approach the time of hatching this color disappears and gives place to a dull, leaden hue.

The interval between the time of depositing and hatching of the eggs for the first brood varies considerably, and the latter may be greatly retarded by inclement weather. Usually, however, not more than ten days are consumed in maturing the embryo within. The eggs of the summer brood seldom require more than one week to hatch.

Without check the offspring of one female moth might in a single season (assuming one-half of her progeny to be female and barring all checks) number 125,000 caterpillars in early Fall—enough to ruin the shade trees of many a fine street.

THE LARVÆ (Plate X, Figs. 2*a*, 2*b*, and 2*c*).—The caterpillars just born are pale yellow, with two rows of black marks along the body, a black head, and with quite sparse hairs. When full grown they generally appear pale yellowish or greenish, with a broad dusky stripe along the back and a yellow stripe along the sides; they are covered with whitish hairs, which spring from black and orange-yellow warts. The caterpillar is, however, very variable both as to depth of coloring and as to markings. Close observations have failed to show that different food produces changes in the coloration; in fact, nearly all the various color varieties may be found upon the same tree. The fall generation is, however, on the whole, darker, with browner hairs, than the spring generation.

As soon as the young caterpillars hatch they immediately go to work to spin a small silken web for themselves, which by their united efforts soon grows large enough to be noticed upon the trees. Under this protecting shelter they feed in company, at first devouring only the green upper portions of the leaf, and leaving the veins and lower skin unmolested. As they increase in size they enlarge their web by connecting it with the adjoining leaves and twigs; thus as they gradually work downwards their web becomes quite bulky, and, as it is filled with brown and skeletonized leaves and other discolored matter as well as with their old skins, it becomes quite an unpleasant feature in our public thoroughfares and parks. The caterpillars always feed underneath these webs; but as soon as they approach maturity, which requires about one month, they commence to scatter about, searching for suitable places in which to spin their cocoons. If very numerous upon the same tree the food-supply gives out, and they are forced by hunger to leave their sheltering homes before the usual time.

When the young caterpillars are forced to leave their web they do not drop suddenly to the ground, but suspend themselves by a fine silken thread, by means of which they easily recover the tree. Grown caterpillars, which measure 1.11 inches in length, do not spin such a thread. Both young and old ones drop themselves to the ground without spinning when disturbed or sorely pressed by hunger.

PUPA AND COCOON (Plate X, Figs. *2d* and *2e*).—Favorite recesses selected for pupation are the crevices in bark and similar shelters above ground, in some cases even the empty cocoons of other moths.* The angles of tree-boxes, the rubbish collected around the base of trees and other like shelter are employed for this purpose, while the second brood prefer to bury themselves just under the surface of the ground, provided that the earth be soft enough for that purpose. The cocoon itself is thin and almost transparent, and is composed of a slight web of silk intermixed with a few hairs, or mixed with sand if made in the soil.

The pupa is of a very dark-brown color, smooth and polished, and faintly punctuate. It is characterized by a swelling or bulging about the middle. It is 0.60 inch long and 0.23 inch broad in the middle of its body.

THE MOTH (Plate X, Figs. 1 *a–j*, and *2f*).—The moths vary greatly, both in size and coloration. They have, in consequence of such variations, received many names, such as *cunea* Drury, *textor* Harr., *punctata* Fitch, *punctatissima* Smith. But there is no doubt, as proven from frequent breeding of specimens, that all these names apply to the very same insect, or at most to slight varieties, and that Drury's name *cunea*, having priority, must be used for the species.

The most frequent form observed in the vicinity of Washington is white, with a very slight fulvous shade. It has immaculate wings, tawny-yellow front thighs, and blackish feet. In some specimens the tawny thighs have a large black spot, while the shanks on the upper surface are rufous. In many all the thighs are tawny-yellow, while in others they have scarcely any color. Some specimens (often reared from the same lot of larvæ) have two tolerably distinct spots on each front wing, one at base of fork on the costal nerve and one just within the second furcation of the median nerve. Other specimens, again, have their wings spotted all over and approach the form *punctatissima*, described as the Many-spotted Ermine-moth of the Southern

* We have known the substantial cocoon of *Cerura* to be used for this purpose.

States. The wings of the moths expand from one inch and a quarter to one inch and three-eighths. The male moth, which is usually a little smaller, has its antennæ doubly feathered beneath, while those of the female possess instead two rows of minute teeth.

The pupa state lasts from six to eight days for the summer brood, while the hibernating brood, however, requires as many months, according to the latitude.

INJURY DONE IN 1886.

During the past year the city of Washington, as well as its vicinity, was entirely overrun by the caterpillars. With the exception of trees and plants the foliage of which was not agreeable to the taste of this insect, all vegetation suffered greatly. The appended list of trees, shrubs, and other plants shows that comparatively few kinds escaped entirely. The fine rows of shade trees which grace all the streets and avenues appeared leafless and covered with throngs of the hairy worms. Excepting on the very tall trees, in which the highest branches showed a few leaves too high for the caterpillars to reach, not a vestige of foliage could be seen. The trees were not alone bare, but were still more disfigured by old and new webs made by the caterpillars, in which bits of leaves and leaf-stems, as well as the dried frass, had collected, producing a very unpleasant sight. The pavements were also constantly covered with this unsightly frass, and the empty skins of the various molts the caterpillars had to undergo were drifted about with every wind and collected in masses in corners and tree-boxes. The parks fared a little better. Because of the great variety of trees planted there some escaped entirely, while others showed the effect of the united efforts of so many hungry caterpillars only in a more or less severe degree. The grassy spots surrounding the different groups of trees had also a protective influence, since the caterpillars do not like to travel over grass, except when prompted by a too ravenous hunger. The rapid increase of this insect is materially assisted by the peculiar method of selecting shade trees for the city. Every street has but one kind of shade tree; rows of them extend for miles, and the trees are planted so close together that their branches almost interlace. Thus there is no obstacle at all to the rapid increase and distribution of the caterpillars. If different kinds of trees had been planted so as to alternate, less trouble might be experienced. Plate XI shows a view of Fourteenth street, taken in late September, which illustrates the point, the Poplars on the west side being completely defoliated as far as the eye can reach, while the Maples on the east are almost untouched.

As long as the caterpillars were young and still small the different communities remained under cover of their webs and only offended the eye; but as soon as they reached maturity and commenced to scatter, prompted by the desire to find suitable places to spin their cocoons and transform to pupæ, matters became more unpleasant and complaints were heard from all those who had to pass such infested trees. In many localities no one could walk without stepping upon caterpillars; they dropped upon every one and every thing; they entered flower and vegetable gardens, porches and verandas, and the house itself, and became, in fact, a general nuisance.

The chief damage done to vegetation was confined to the city itself, although the caterpillars extended some distance into the surrounding country. There, however, they were more local and almost entirely

confined to certain trees, and mainly so to the White Poplar and the Cotton-wood. Along the Baltimore and Potomac Railroad tracks these trees were defoliated as far as five miles from the Capitol. In Georgetown the caterpillars were equally noxious, but in the adjoining forests but very few webs could be seen.

The proportionate injury to any given species of tree is to some extent a matter of chance; and in some respects a year of great injury, as 1886, is not a good year to study the preferences of a species, because when hard pressed for food the caterpillars will feed upon almost any plant, though it is questionable whether they can mature and transform on those which they take to only under the influence of such absolute necessity. Again, the preference shown for particular trees is more the result of the preference of the parent moth than of its progeny in a case of so general a feeder as the Fall Web-worm. We had a very good illustration of this in Atlantic City last autumn. The caterpillars were exceedingly abundant during autumn along this portion of the Atlantic coast, especially on the trees above named. We studied particularly their ways upon one tree that was totally defoliated by September 11. The bulk of the caterpillars were then just through their last molt, though others were of all ages, illustrating different hatchings. There was an instinctive migration of these larvæ of all sizes, and the strength of their food-habit once acquired from birth upon a particular tree was well illustrated. At first the worms passed over various adjacent plants, like Honeysuckles, Roses, &c., the leaves of which they freely devour if hatched upon them; but as the migrating swarm became pressed with hunger they finally fell upon these, and even upon plants like the Peach and Ailanthus, which ordinarily are passed over. They would even pounce upon any food, and a rotten apple placed in their way was soon literally swarming with them and sucked dry.

In a general way it may be stated that conifers, grapes, and most herbaceous plants are free from their attacks, and it is very doubtful whether the species can mature upon them.

The list of plants which follows is arranged according to the relative damage to the foliage in the city of Washington. The three first named are most subject to attack, and in fact are almost always defoliated.

PROPORTIONATE INJURY TO DIFFERENT PLANTS AND SHADE TREES.

The damage done in the city of Washington was exceptional, but so was also the general damage throughout the New England States, if not throughout the country. In New England the greater predilection which the species showed for Poplar, Cottonwood, and the ranker growing Willows was everywhere manifest, and so much was this the case, that the destruction of the first brood on these trees would have substantially lessened the damage to other trees.

Plants marked 1 have lost from 75 to 100 per cent. of their foliage.
Plants marked 2 have lost from 50 to 75 per cent. of their foliage.
Plants marked 3 have lost from 25 to 50 per cent. of their foliage.
Plants marked 4 have lost from 1 to 25 per cent. of their foliage.

Plants marked with two figures have shown the relative immunity or injury indicated by both, the variation being in individual trees.

1. *Negundo aceroides* Mœnch. (Box Elder.)
1. *Populus alba* L. (European White Poplar.)
1. *Populus monilifera* Ait. (Cottonwood.)

1–2. *Populus balsamifera* L. (Balsam Poplar.)
1–2. *Populus tremuloides* Mich'x. (American Aspen.)
1–2. *Fraxinus americana* L. (White Ash.)
1–2. *Fraxinus excelsior* L. (European Ash.)
1–2. *Sambucus canadensis* L. (Elder.)
1–2. *Pyrus* species. (Cultivated Pear and Apple.)
1–2. *Prunus avium* and *cerasus* L. (Cherries.)
1–4. *Syringa vulgaris* L. (Lilac.)
1–4. *Ilex* species. (Holly.)
2. *Platanus occidentalis* L. (Sycamore.)
2. *Salix* species. (Willow.)
2. *Tilia americana* L. (American Linden.)
2. *Tilia europœa* L. (European Linden.)
2. *Populus dilatata* Ait. (Lombardy Poplar.)
2. *Ulmus americana* L. (American White Elm.)
2–3. *Ulmus fulva* Mich'x. (Slippery Elm.)
2–3. *Prunus armenica* L. (Apricot.)
2–3. *Alnus maritima* Muhl. (Alder.)
2–3. *Betula alba* L. (White Birch.)
2–3. *Viburnum* species. (Haw or Sloe.)
2–3. *Lonicera* species. (Honeysuckles.)
2–3. *Prunus americana* Marsh. (Wild Red Plum.)
2–3. *Celtis occidentalis* L. (Hackberry.)
2–3. *Rosa* species. (Rose.)
2–3. *Gossypium album* Ham. (Cotton.)
2–3. *Cephalanthus occidentalis* L. (Button Bush.)
2–3. *Vitis* species. (Grape-vine.)
2–4. *Convolvulus* species. (Morning Glory.)
2–4. *Acer saccharinum* Wang. (Sugar Maple.)
2–4. *Geranium* species. (Geranium.)
3. *Betula nigra* L. (Red Birch.)
3. *Tecoma radicans* Juss. (Trumpet Creeper.)
3. *Symphoricarpus racemosus* Mich'x. (Snowberry.)
3. *Larix europœa* Del. (European Larch.)
3. *Corylus americana* Walt. (Hazel-nut.)
3. *Quercus alba* L. (White Oak.)
3. *Diospyros virginiana* L. (Persimmon.)
3. *Carya* species. (Hickory.)
3. *Juglans* species. (Walnut.)
3. *Wistaria sinensis* Del. (Chinese Wisteria.)
3. *Wistaria frutescens.* (Native Wisteria.)
3. *Amelanchier canadensis* T. and G. (Shad-bush.)
3. *Cratœgus* species. (Haw.)
3. *Rubus* species. (Blackberry.)
3. *Spirœa* species. (Spiræa.)
3. *Ribes* species. (Currant and Gooseberry.)
3. *Staphylea trifolia* L. (Bladder Nut.)
3–4. *Cydonia vulgaris* Pers. (Quince.)
3–4. *Asimina triloba* Dun. (Pawpaw.)
3–4. *Berberis canadensis* Pursh. (Barberry.)
3–4. *Catalpa bignonioides* Walt. (Indian Bean.)
3–4. *Catalpa speciosa* Ward. (Bignonia.)
3–4. *Euonymus atropurpureus* Jaeg. (Burning Bush.)
3–4. *Cupressus thyoides* L. (White Cedar.)
3–4. *Juniperus virginiana* L. (Red Cedar.)
3–4 *Cornus florida* L. (Flowering Dogwood).

3–4. *Cornus alternifolia* L. (Alternate-leaved Dogwood.)
3–4. *Carpinus americana* Mich'x. (Hornbeam.)
3–4. *Castanea americana* Mich'x. (American Chestnut.)
3–4. *Castanea pumila* Mich'x. (Chinquapin.)
3–4. *Ostrya virginica* Willd. (Hop Hornbeam.)
3–4. *Quercus coccinea* Wang. (Scarlet Oak.)
3–4. *Quercus phellos* L. (Willow Oak.)
3–4. *Quercus prinus* L. (Chestnut Oak.)
3–4. *Quercus rubra* L. (Red Oak.)
3–4. *Diospyros kaki* L. (Japan Persimmon.)
3–4. *Buxus sempervirens* L. (Common Box.)
3–4. *Hamamelis virginica* L. (Witch Hazel.)
3–4. *Sassafras officinale* Nees. (Sassafras.)
3–4. *Cercis canadensis* L. (Red Bud.)
3–4. *Hibiscus syriacus* L. (Tree Hibiscus.)
3–4. *Rhamnus alnifolius* L'Her. (Alder-leaved Buckthorn.)
3–4. *Prunus virginiana* L. (Choke Cherry.)
3–4. *Persica vulgaris* Millan. (Peach.)
3–4. *Æsculus hippocastanum* L. (Horse Chestnut.)
3–4. *Paulownia imperialis* Seeb. (Cigar-tree.)
3–4. *Ailanthus glandulosus* Daf. (Tree of Heaven.)
3–4. *Maclura aurantiaca* Nutt. (Osage Orange.)
3–4. *Ampelopsis quinquefolia* Mich'x. (Virginia Creeper.)
3–4. *Clematis* species. (Clematis.)
3–4. *Trifolium* species. (Clover.)
3–4. *Helianthus* species. (Sunflower.)
3–4. *Jasminum* species. (Jessamine).
3–4. *Ficus carica* L. (Fig.)
4. *Rhus cotinus* L. (Smoke Tree.)
4. *Pinus* species. (Pine.)
4. *Taxus* species. (Yew.)
4. *Nyssa multiflora*, Wangerh. (Sour Gum.)
4. *Fagus ferruginea* Ait. (Beech.)
4. *Kalmia* species. (Laurel.)
4. *Rhododendron* species. (Rhododendron.)
4. *Ricinus communis* L. (Castor-oil Plant.)
4. *Liquidambar styraciflua* L. (Sweet Gum.)
4. *Gleditschia triacanthos* L. (Honey Locust.)
4. *Gymnocladus canadensis*, Lamb. (Kentucky Coffee Tree.)
4. *Robinia pseudacacia* L. (Locust.)
4. *Liriodendron tulipifera* L. (Tulip Tree.)
4. *Magnolia* species. (Magnolia.)
4. *Chionanthus virginicus* L. (Fringe Tree.)
4. *Ligustrum vulgare* L. (Privet.)
4. *Zanthoxylum americanum* M. (Prickly Ash.)
4. *Acer dasycarpum* Ehrh. (White or Silver Maple.)
4. *Acer rubrum* Wangert. (Red Maple.)
4. *Æsculus flava*, Ait. (Sweet Buckeye.)
4. *Æsculus glabra* Willd. (Ohio Buckeye.)
4. *Morus rubra* L. (Red Mulberry.)

Trees in the vicinity of the White Poplar and Cottonwood suffer most. Even trees usually not injured, as, for instance, the Sugar Maple, are often badly defoliated when in such contiguity.

This list contains a number of plants not usually injured by these caterpillars. In some cases the injury was due to the fact that twigs containing the web with its occupants had been pruned from the tree

and thrown near plants, instead of being burned at once or otherwise destroyed.

In other cases the injury is due to the peculiar position of the plant injured, *i. e.* under a tree infested by the caterpillars. These, when fully grown, commence to scatter, and dropping upon the plant underneath the tree, soon defoliated it without actually making their home upon it. The great number thus dropping from a large tree will soon defoliate any smaller plant, even if each caterpillar takes but a mouthful by way of trial. Thus Holly, a plant not usually eaten by these insects, soon became denuded. Other plants, unpalatable or even obnoxious to the caterpillars, are sometimes destroyed by the multitudes in their search for more suitable food.

Hungry caterpillars, leaving a denuded tree in search of food, wander in a straight line to the next tree, sometimes a distance of 25 feet, showing that they possess some keen sense to guide them. If such a tree offers unsuitable food, they still explore it for a long time before deserting it. In this manner two columns of wandering caterpillars are formed, which frequently move in opposite directions.

PECULIAR EFFECT OF DEFOLIATION UPON SOME PLANTS.

During the early part of October many trees, mainly Apple and Pear, which had been entirely denuded of their foliage by the caterpillars, showed renewed activity of growth. Some had a few scattered flowers upon them, others had one or two branches clothed with flowers, while in some few cases the whole tree appeared white. It looked as if the trees were covered with snow, since they lacked the green foliage usually seen with blossoms in spring. Some few flowers were also observed upon badly defoliated Cherry trees. Even as late as the middle of November, owing perhaps also to the pleasantly warm weather, some few flowers could be observed upon some imported plants belonging to the genus *Spiræa* and upon the Chinese Red Apple. All these plants usually flower early in spring. The caterpillars, having entirely defoliated the tree, produced thus an artificial period of rest, or winter, which was followed by unseasonable budding and flowering. Such a result often follows summer denudation by any insect, and we have referred to some remarkable cases in our previous writings.*

ENEMIES OF THE WEB-WORM OTHER THAN INSECTS.

The caterpillars have comparatively few enemies belonging to the vertebrate animals. This is not owing to any offensive odor or to any other means of defense, but it is entirely due to their hairiness. Chickens, and even the omnivorous ducks, do not eat them; if offered to the former they pick at these morsels, but do not swallow them.

The English Sparrow has, in this case at least, not proven of any assistance whatever. Indeed, as before stated, its introduction and multiplication have greatly favored the increase of the worms.

The "pellets" of a Screech-owl (*Scops asio*), found in the vicinity of Baltimore, Md., and examined by Mr. Lugger, consisted apparently almost entirely of the hairs of these caterpillars, proving that this useful bird had done good service.

Perhaps the statement may be of interest, that this little owl is

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*See Eighth Report on the Insects of Missouri, p. 121.

getting much more common in the vicinity of such cities in which the English Sparrows have become numerous, and that the imported birds will find in this owl as bold an enemy as the Sparrow-hawk is to them in Europe, and even more dangerous, since its attacks are made towards dusk, at a time when the Sparrow has retired for the night, and is not as wide awake for ways and means to escape.

If our two Cuckoos, the Black-billed as well as the Yellow-billed species, could be induced to build their nests within the city limits or in our parks, we should gain in them two very useful friends, since they feed upon hairy caterpillars.

The common Toad (*Bufo americana*) has eaten great numbers of these caterpillars, as shown by dissections made by Mr. Lugger, and it should be carefully protected, instead of being tormented or killed by boys, or even grown people. The Toad is always a useful animal, and ought to be introduced in all gardens and parks.

The following species of spiders were observed to eat the caterpillars, viz, *Marpessa undata* Koch, and *Attus* (*Phydippus*) *tripunctatus*. Neither species builds a web, but obtains its prey by boldly leaping upon it; they are, in consequence of such habits, frequently called tiger spiders. The former was exceedingly common last year, more so than for many previous years, thus plainly indicating that the species did not suffer for lack of food. This species is usually found upon the trunks of trees, and is there well protected by its color, which is like that of the bark. It hides in depressions and cracks of the bark, and, jumping upon the passing game, or, catlike approaching it from behind, it thrusts its poisonous fangs into the victim, which soon dies and is sucked dry. The *Attus* has similar habits, but is still more cautious; it usually hides under loose bark. Both spiders are wonderfully active and kill large numbers of caterpillars. Their large and flat egg-masses can be found during the winter under dead bark and in cracks. Both species hibernate in silken nests in similar localities.

PREDACEOUS INSECT ENEMIES.

The caterpillars of this moth have quite a number of external enemies, which slay large numbers of them. The well-known Rear-horse (*Mantis carolina*) seems to be very fond of the caterpillars. The so-called Wheel-bug (*Prionidus cristatus*) has proved to be one of our best friends in reducing the numbers of the caterpillars. This insect was formerly by no means very common in cities, but of late years it has greatly increased in numbers, and is now a well-known feature in all our public parks and such streets as possess shade trees. Outside of the city it is rarely met with; nor does it extend much farther North than Washington. It is, like the Mantis, in all its stages a voracious feeder upon insects, slaying alike beneficial and noxious ones. The bright-red larvæ and pupæ, also carnivorous, are seen in numbers during the summer; they usually remain together until hunger forces them to scatter. They assist each other in killing larger game, and are to this extent social. The Wheel-bug could be observed almost anywhere last summer, but usually motionless, stationed upon the trunks of trees, waiting for the approach of an insect. If one comes near, it quite leisurely inserts its very poisonous beak and sucks the life-blood of its victim. When this becomes empty it is hoisted up in the air, as if to facilitate the flow of blood, until eventually it is thrown away as a mere shriveled skin. The

appetite of the Wheel-bug is remarkable, whenever chances offer to appease it to the fullest extent. Frequently, however, times go hard with it, and notwithstanding it is very loath to change a position once taken, it is sometimes forced to seek better hunting-grounds, and takes to its wings. The Wheel-bug has been observed to remain for days in the same ill-chosen position—for instance upon the walls of a building—waiting patiently for something to turn up. It is slow in all its motions, but withal very observant of everything occurring in its neighborhood, proving without doubt great acuteness of senses. It does not seem to possess any enemies itself, and a glance at its armor will indicate the reason for this unusual exemption.* During warm weather this bug possesses a good deal of very searching curiosity, and a thrust with its beak filled with poison is very painful indeed. Boys call it the "blood-sucker," a misnomer, since it does not suck human blood. Its eggs are laid during the autumn in various places, but chiefly upon smooth surfaces of the bark of tree trunks, and frequently in such a position as to be somewhat protected against rain by a projecting branch. The female bug always selects places the color of which is like that of the eggs, so that they are not easy to see, notwithstanding their large size.

Euschistus servus Say is another hemipterous insect that preys upon the caterpillar of *H. textor*, and in a similar manner to the Wheel-bug. It is a much smaller, but also a very useful insect.

Podisus spinosus, Dall., in all its stages, was quite numerous during the caterpillar plague. Its brightly-colored larvæ and pupæ were usually found in small numbers together, but as they grew older they became more solitary in their habits. All stages of this insect frequent the trunks and branches of trees, and are here actively engaged in feeding upon various insects. As soon as one of the more mature larvæ or pupæ has impaled its prey the smaller ones crowd about to obtain their share. But the lucky captor is by no means willing to divide with the others, and he will frequently project his beak forward, thus elevating the caterpillar into the air away from the others. The habit of carrying their food in such a difficult position has perhaps been acquired simply to prevent others from sharing it. A wonderful strength is necessary to perform such a feat, since the caterpillar is sometimes many times as heavy as the bug itself. The greediness of this bug was well illustrated in the following observation: A pupa of *P. spinosus* had impaled a caterpillar, and was actively engaged in sucking it dry; meanwhile a Wheel-bug utilized a favorable opportunity and impaled the pupa without forcing the same to let go the caterpillar. The elasticity of the beak of these bugs must be very great; they can bend it in any direction and yet keep it in sucking operation. The poison contained in the beak must act very rapidly, since the caterpillars impaled by it squirm but a very short time and then become quiet.

FUNGUS DISEASE OF THE WEB-WORM.

In our Fourth Missouri Entomological Report, p. 88, we called attention to the fact that the fungus disease of the domestic Silk-worm, called in France *Muscardine*, and supposed to be due to the development in the worms of the fungus *Botrytis bassiana*, or a disease which had not yet been distinguished from it, had made its appearance

*Its eggs, however, are pierced by a little egg-parasite—*Eupelmus reduvii* Howard.

among Silk-worms, both imported and wild, in some of the Eastern States, and that in the fall of 1870 it was so common around Saint Louis that we found hundreds of hairy caterpillars stiffly fastened to their food-plants and covered with the white efflorescence. On several occasions in Saint Louis we found the *Hyphantria* larvæ generally affected by it.

The latest authority upon this fungus (Saccardo) gives it as living upon Bombycid larvæ, particularly upon the Silk-worm of commerce, in France, Italy, and North America. *Botrytis tenella*, which he described in his "*Fungi Italicæ*" as a new species, he now considers as only a variety of *B. bassiana*. This variety is found upon dipterous larvæ and pupæ, upon wasps of the genus *Vespa*, and upon the larvæ of the coleopterous genus *Melolontha*. (P. A. Saccardo, *Sylloge Hyphomycetum omnium huscusque cognitorum*, Vol. IV, p. 119, Patavia, 1886.)

The first brood of the Web-worms at Washington in 1886 showed in some quite well-defined localities the indications of a fungus disease, which was probably only a variety of this *Botrytis*. It did not become, however, so general as later in the season, when it prevailed everywhere; yet it could be observed that the contagion had started from certain points. In such localities almost all the caterpillars were diseased and died, and large numbers of the dead were huddled together as in life. But when investigated their bodies were hard and dry, and would readily crumble to pieces when pressed, producing an odor like that of some mushrooms. Only full-grown, or rather caterpillars in their last larval skin, were thus affected. The dry remains had retained the original shape, and, if killed but recently by the fungus, their color as well. Before dying the caterpillars had fastened themselves very securely to trunks, twigs, and leaves of various trees, somewhat like the common house-fly, that dies by a similar disease in large numbers during September in our houses and produces around itself such a characteristic halo of white spores. Caterpillars infested by the incipient stages of this disease wander about aimlessly and at an irregular speed; often they halt for some time, then squirm about frantically to start again, and frequently in an opposite direction to the one they were going before. If such a diseased caterpillar is confined to a glass jar and observed, it is soon seen that a white mealy substance gradually grows out of all the soft spaces between the segments, which eventually covers the whole insect, leaving generally only the black head and tips of hairs visible. Before long many spores are scattered about, forming a circle of white dust around the caterpillar, and, if not arrested by an obstruction in its expulsion, the halo thus formed is quite regular and about 2 inches in diameter. Outdoors this white dust is but seldom observed, because even the slightest draft of air will carry it away and drift it about. Even the white mealy substance adhering to the caterpillar itself is usually swept away, and the victims look very much like healthy caterpillars; but they darken with time, and eventually drop to the ground. The magnifying-glass, however, still reveals some spores adhering to the hairs upon the under side and upon the bark or leaf of the tree in the immediate neighborhood.

This fungus kills caterpillars even after they have made their cocoons. Nor does the pupa escape. In the latter case the spores form a white crest over every suture of the thoracic segments; the abdominal segments, however, remain free from it. Evidently the caterpillars were nearly full-grown when attacked by the disease,

and possessed vigor enough to transform into pupæ; later the fungus grew, and pressing the chitinous portion of the pupa apart, forced itself to the air to fructify.

Plants not usually eaten by the caterpillars, as well as others not eaten at all, have upon them the largest numbers of caterpillars killed by the fungus, provided that they grew in the vicinity of suitable food-plants. Perhaps unsuitable food, predisposing the caterpillars for any disease, is one of the causes of the innumerable host killed by this fungus.

The white cocoons of a parasite (*Apanteles hyphantriæ*) were in some cases observed to be covered with similar fungus spores. Opening such cocoons it was seen that the spores were not simply blown upon the silk and there retained, but that they came from the victim within, and had forced their way through the very dense silken mass.

EXPERIMENTS TO OBTAIN PERCENTAGE OF DISEASED CATERPILLARS.

Experiment I:

One hundred and twenty-five nearly grown caterpillars were gathered (October 7, 1886) at random in one of our public parks. They were imprisoned in large glass jars, and daily supplied with suitable food.

Result, October 18, 1886:

11 apparently healthy pupæ.
3 deformed pupæ.
18 yellow cocoons of *Meteorus hyphantriæ.*
9 dead pupæ, killed by fungus or otherwise.
84 dead caterpillars, killed by fungus or otherwise.

125

In the earth of the jar were found 17 pupæ of Tachina flies, leaving 67 caterpillars and 9 pupæ killed by the fungus, or 61 per cent.

Experiment II:

One hundred and twenty-five nearly grown caterpillars were gathered (October 7, 1886) from a trunk of a soft maple (unsuitable food) and treated as above.

Result, October 18, 1886:

8 apparently healthy pupæ.
1 deformed pupa.
7 yellow cocoons of *Meteorus hyphantriæ.*
3 dead pupæ, killed by fungus or otherwise.
104 dead caterpillars, killed by fungus or otherwise.
2 cocoons containing Tachina larvæ.

125

In the earth of the jar were found 28 pupæ of Tachina flies, leaving 76 caterpillars and 3 pupæ killed by fungus, or 63 per cent.

In both experiments it has been assumed that each Tachina fly had killed one caterpillar.

On November 15, 1886, the jars were again investigated and it was found that a number of the pupæ had been killed by the fungus since October 18, 1886, and that in fact all the remaining ones appeared diseased. The percentage of death by the fungus in the two experiments was thus increased to 63 per cent. in Experiment I and to 67 per cent in Experiment II.

TRUE PARASITES OF THE WEB-WORM.

Up to the present time no parasites of this insect have ever been recorded. On August 18, 1883, we bred a number of egg-parasites from a batch of eggs found upon a willow leaf at Washington, but unfortunately no description was made of them at the time, and, as they belonged to the soft-bodied genus *Trichogramma*, the specimens have now become so much shriveled and altered that they are unfit for descriptive purposes. We noticed after our return from Europe in September of this year that, at a number of points in New England, the worms were quite commonly attacked by parasites, and careful investigation at Washington by Mr. Lugger showed the presence of no less than five distinct species of primary parasites in addition to the *Trichogramma* just mentioned. These will be considered in some detail. The first was a new egg-parasite, which we have named *Telenomus bifidus;* the others were all parasitic on the larvæ, and consisted of a Braconid (*Meteorus hyphantriœ* n. sp.); a Microgaster (*Apanteles hyphantriœ,* n. sp.); an Ophionid (*Limneria pallipes* Prov.), and a Tachinid, which, though probably new, we shall not attempt to describe. These last four have been mentioned in about the order of their relative abundance and consequent importance. An astonishing number of Web-worms were killed by the four parasites, and so many died from this cause and from the fungus disease previously mentioned as to fully warrant the prediction of almost complete immunity for the summer of 1887.

In addition to these parasites found last Fall, the note-books of the Division show a prior breeding of another primary parasite, which will not be treated in detail here on account of insufficient material. It is an external feeder on the larva and belongs to the genus *Euplectrus.* It is closely related to *E. platyhypenœ,* described by Mr. Howard in Bulletin 5 of this Division.

We have found, however, that three of these primary parasites of the Web-worm, viz, the *Apanteles*, the *Limneria,* and the *Meteorus,* were killed off at a serious rate late in the season by secondary parasites, most of which belong to the family *Chalcididœ* with the exception of three species of the Ichneumonid genus *Hemiteles.* So extensive has been this killing off of the primary parasites by the secondary, that were not the fates of the three classes, viz, the plant-feeder, the primary and the secondary parasites so interwoven, the destruction of these beneficial insects might be considered a serious matter in dealing with the plant-feeder.

We have not taken time to determine these secondary parasites specifically, but give a little table showing the number of species concerned, mentioning them only by their genera:

SECONDARY PARASITES.

On *Apanteles:*

1. *Hemiteles* sp.
2. *Elasmus* sp.
3. *Eupelmus* sp.
4. *Panstenon* sp.
5. *Cirrospilus* sp.
6. *Pteromalus* sp.
7. *Pteromalus* sp.

On *Meteorus hyphantriæ*:
1. *Hemiteles* sp. (= 1 on *Apanteles*).
2. *Spilochalcis* sp.
3. *Hemiteles utilis* Nort.
4. *Eupelmus* sp. (= 3 on *Apanteles*).
5. *Hemiteles* sp.
6. *Pteromalus* sp. (= 6 on *Apanteles*).
7. *Pteromalus* sp. (= 7 on *Apanteles*).

On *Limneria pallipes* Prov.:
1. *Eupelmus* sp. (= 3 on *Apanteles*).
2. *Tetrastichus* sp.
3. *Pteromalus* sp. (= 6 on *Apanteles*).
4. *Pteromalus* sp. (= 7 on *Apanteles*).
5. *Elasmus* sp. (= 2 on *Apanteles*).

THE TELENOMUS EGG-PARASITE.—A single egg of *H. cunea* is a very small affair, yet it is large enough to be a world for this little parasite, which undergoes all its transformations within it, and finds there all the food and lodgment required for the short period of its life. In several instances batches of eggs of this moth were parasitized, and instead of producing young caterpillars they brought forth the tiny insects of this species. The batches of parasitized eggs were found July 27 upon the leaves of Sunflower. Judging from this date, it was the second brood of moths which had deposited them. There can be no doubt, however, that eggs produced by moths emerging from their cocoons in early spring had been parasitized as well. The female *Telenomus* was also observed August 2, busily engaged in forcing its ovipositor into the eggs and ovipositing therein. The female insect is so very intent upon its work that it is not easily disturbed, and one can pluck a leaf and apply a lens without scaring it away. The eggs soon hatch inside the large egg of the moth, and the larvæ produced soon consume the contents. This egg-parasite is a very useful friend, nipping the evil in the bud, so to speak.

This parasite is new, and may be characterized as follows:

TELENOMUS BIFIDUS n. sp. ♂ ♀.—Average length, 0.75mm; average expanse, 1.7mm. Color of body, black throughout. *Head* three times as broad as long when seen from above; face, especially in the middle, lustrous and without sculpture; vertex polished and without a carina behind lateral ocelli; antennæ black, except bulla, which is honey-yellow, 11-jointed, joints 2 and 3 subequal in length. *Thorax:* Mesonotum very delicately punctulate and furnished with a moderately dense, fine, whitish pile; no parapsidal sutures; legs yellow, except coxæ, femora, and last joints of all tarsi, which are black or blackish; tibial spur of front legs bifid when seen under a high power, and corresponding first tarsal joint furnished with a fine and strong comb of bristles; fore wings with 11 costal bristles and with 3 cells visible in stigmal club. *Abdomen* with the second segment striate only at base.

Described from 5♀, 2♂, bred July 27, 1886, from eggs of *Hyphantria cunea* collected in the District of Columbia.

This species belongs nearest to *T. phalœnarum* Nees, of Europe, which has been bred from the eggs of *Porthesia chrysorrhea* by Wachtl, from eggs of *Panolis piniperda* by Nördlinger, and from eggs of an unknown Noctuid on the leaves of *Æsculus hippocastanum* by Mayr. (See Mayr, "*Ueber die Schlupfwespengattung Telenomus*" Verh. d. k.-k. zoöl. Ges., Wien, 1879, p. 709.)

THE METEORUS PARASITE OF THE WEB-WORM (Plate X, fig. 4.)—This parasite has performed very good service during the caterpillar plague, and has done much to check any further increase of the Web-

worm. During the earlier part of the summer this insect was not very numerous, but sufficient proofs in form of empty cocoons were observed to indicate at least one earlier brood. Towards the end of September, and as late as the 15th of October, very numerous cocoons of a second brood were formed; they could be found in all situations to which the caterpillar itself had access. But the great majority of them were suspended from the trunks* and branches of trees, and chiefly from near the base of the trunk. Each represents the death of one nearly full-grown caterpillar, since the latter harbors but one larva of the parasite. A careful watch was kept to see how such a suspended cocoon was formed, but in vain. Once a larva had just started to make a cocoon, but became detached, and dropped out of the orifice and commenced a new one. The larva, suspended by the mandibles, evidently spins at first loose, irregular, horizontal loops around its body, until a loose cradle is formed. The silk secreted for this purpose hardens very rapidly when exposed to the air. When secure inside this cradle it lets go its hold with the mandibles, and finishes the soft inside cocoon in the usual manner. If the larva has dropped to the ground, it still makes an outer loose cocoon, but the silken threads are thicker and much more irregular. In cocoons made during a high wind, the threads that suspend them are much longer, reaching sometimes the length of 4 inches; the more normal length varies from 1½ to 2 inches.

To find out the length of time which this insect occupies in maturing inside the cocoon 44 freshly made cocoons were put in a glass jar. With remarkable regularity, but ten days were consumed by the insect in changing from the larval to the winged form. The winged *Meteorus* issues through a perfectly round hole at the lower end of the cocoon by gnawing off and detaching a snugly fitting cap. The several secondary parasites of the *Meteorus* which we have mentioned all leave the cocoon of their host by smaller holes cut through the sides. Most of the adult *Meteorus* had issued by the 1st of November; but it is possible that some may remain in their cocoons until spring.

In order to obtain the proportion between the *Meteorus* raised from cocoons and its parasites (*i. e.*, secondary parasites of *Hyphantria*), 450 cocoons were confined in a glass jar the latter part of September. Up to the first week in November only 70 specimens were bred from these cocoons, the rest giving out secondary parasites, which continued to issue up to date of writing (December 20, 1886). Thus only 16 per cent. of the cocoons produced the primary, while 84 per cent. produced secondary parasites. The insect is new, and we submit the following description:—

METEORUS HYPHANTRIÆ n. sp.—♀. Length, 5^{mm}; expanse, 11^{mm}. Comes nearest to *Meteorus communis* Cress., being, however, a larger species. Its cocoons are also larger and of a darker yellow-brown in color. General color, honey-yellow. The irregular reticulation of the metanotum shows less tendency to arrange itself in longitudinal carinæ, particularly into one median and two sublateral. The fine longitudinal impressed aciculations of the first abdominal segment are nearly parallel in *hyphantriæ*, while in *communis* the middle ones converge strongly towards the center behind. The general color is, as in *communis*, yellowish-ferruginous or honey-yellow. In general, *hyphantriæ* has more dark markings than *communis*. The antennæ are dusky at tip; the mandibles are brown at tip; the mesoscutum has two nearly black patches at sides and often a dusky stripe down middle; the metanotum is usually entirely dark, as is also the first joint of the abdomen above; the rest of the abdomen has two larger or smaller dark spots on each side; the sheaths of the

* In one instance only, the cocoon of this parasite was found inside that of its host.

ovipositor are dark, especially at base, and the ovipositor itself is honey-yellow; the legs are all honey-yellow except the tips of the hind tibiæ, which are dark.

♂.—Resembles the female, with the usual structural differences. Varies considerably in color, some specimens being almost immaculate, while others are marked like the female. Wing venation in both sexes varies in no way from that of *communis*, and but slightly from that in other species of the genus; in that the second submarginal cell is subquadrate, broadening slightly posteriorly, and in the first transverse cubital nervure being confluent with the recurrent nervure.

Described from 18 ♀, 9 ♂ specimens, all bred in District of Columbia from cocoons collected near remains of larvæ of *Hyphantria cunea*.

THE MICROGASTER PARASITE OF THE WEB-WORM.—This insect was about as numerous as the *Meteorus*, and did equally good service in preventing a further increase of the caterpillars. It appeared somewhat earlier in the season, and had killed only half-grown caterpillars. From the numerous old and empty cocoons in early summer it was plainly seen that a first brood had been quite numerous, and that from these cocoons mainly *Apanteles* had been bred, and not, as during the autumn, mostly secondary parasites. The white silky cocoon is formed almost under the middle of a half-grown caterpillar, and is fastened securely to the object its host happened to rest upon, and but slightly to the host itself, which is readily carried to the ground by wind and rain, and can therefore only be in position in the more sheltered places, such as cracks and fissures of the bark of trees. But one *Apanteles* is found in a caterpillar, so that each white cocoon indicates, like a tombstone, the death of a victim. In some places, and notably upon the trunks of poplars, these cocoons were so numerous as to attract attention; it seemed as if the trunk had been sprinkled with whitewash. But notwithstanding such vast numbers, but two specimens of the architects of these neat cocoons were raised; all the rest had been parasitized by secondary parasites. It is barely possible, however, that some specimens may hibernate in their cocoons, since numbers of them have as yet (December 20, 1886) not revealed any insects. The winged *Apanteles* leaves the cocoon by a perfectly round orifice in the front, by cutting off a little lid, which falls to the ground. Its parasites, however, leave by small holes cut through the sides. These secondary parasites were very common late in September and early in October, and busily engaged in inserting their ovipositors through the tough cocoon into their victim within. It seems as if the cocoons formed early in the season were on an average a little smaller than those formed later.

The cocoons of this *Apanteles* are of a uniform white color, but exceptionally a distinctly yellowish cocoon is found. From these yellow cocoons nothing has so far been bred, but since, as we have elsewhere shown,* the color of the cocoon may vary in the same species, it is probable that the variation here referred to is not specific.

Not quite one-half of 1 per cent of these cocoons produced the insect belonging to it; 99 per cent produced secondary parasites.

APANTELES HYPHANTRIÆ, n. sp.—♀. Length, 3^{mm}. Close to *Apanteles xylina*, Say, with which it may be compared. Differs as follows: Mesonotum without the faint median carina or polished posterior margin; scutellum not polished; first abdominal segment about as broad as long, with a quite distinct median carina, the apex of which is polished, and its posterior margin broadly bilobed. In *A. xylina* the first abdominal segment is rather slender, and longer than wide, without distinct carina and with the apex almost straight. A quite distinct carina on the second segment, wanting in *xylina*. Third abdominal segment coarsely pitted at base,

* Notes on North American Microgasters, &c., Trans. Saint Louis Acad. Sciences, vol. 4, author's separate copy, p. 7.

the rest quite distinctly shagreened; in *xylina* the basal punctuation is less pronounced and the rest of the segment smooth. All coxæ black (in *xylina* the apical half of lower edge of posterior coxæ is reddish); the first joint of metatarsi perceptibly stouter than the other joints (almost like the other joints in *xylina*). Cocoon white and single (in *xylina* the cocoons are enclosed in wooly masses).

Described from two ♀ specimens.

THE LIMNERIA PARASITE OF THE WEB-WORM.—In addition to the two Hymenopterous parasites treated of, a third one has been very numerous, and has done much good in reducing the numbers of caterpillars. This, an Ichneumonid, and a much larger insect, does not form an exposed cocoon like that of the other parasites described. Yet a little attention will soon reveal large numbers of them. Upon the trunks of various trees, but chiefly upon those of the Poplar and Sugar Maple, small colonies of caterpillars, varying in number from 4 to 12, could be observed, which did not show any signs of life. When removed from the tree they appeared contracted, all of the same size, and pale or almost white. A closer inspection would reveal the fact that the posterior portion of the caterpillar had shrunken away to almost nothing, whilst the rest was somewhat inflated, and covered with an unchanged, but bleached skin, retaining all the hairs in their normal position. Opening one of these inflated skins, a long, cylindrical, brown cocoon would be exposed; this is the cocoon of the *Limneria* under consideration. As numbers of such inflated skins would always occur together, it was clearly seen that the same parent *Limneria* had oviposited in all of them. Most of the cocoons were found in depressions of the rough bark, or other protected places. Single ones were but rarely met with. The Hyphantria larvæ in dying had very securely fastened all their legs into the crevices of the bark, so that neither wind nor rain could easily dislodge them. Only half-grown caterpillars had thus been killed. Many of these inflated skins showed in the early part of October a large hole of exit in their posterior and dorsal ends, from which the Ichneumons had escaped. Trying to obtain winged specimens of this parasite, 140 of these cocoons—and only such as were not perforated in any way—were collected and put in a glass jar. Only a single female was produced from all up to time of writing, whilst very large numbers of secondary parasites issued from October 11 to November 20, and doubtless others will appear during the spring of 1887, because some of these inflated skins show as yet no holes of exit.

This parasite is, according to Mr. Cresson, unnamed in the Philadelphia collection, and, after close study of all accessible descriptions, we have decided that it should be placed, temporarily at least, with Provancher's *Limneria pallipes*. The specimens which we have bred correspond with his variety, in which the four anterior femora are pale red. The species is not unlike *L. lophyri* Riley, which we described in our Ninth Missouri Entomological Report from a large series of specimens bred from the larvæ of Abbott's White Pine Worm (*Lophyrus abbottii*), but is smaller and has certain colorational differences.

THE TACHINA PARASITE OF THE WEB-WORM.—The parasites of *H. textor* described so far belong to the order *Hymenoptera*, which furnishes the greatest number of them; but the fly now to be treated is fully as useful as any of the others. We have not named and described this species, on account of the fact that the family to which

it belongs has not been worked up and because the characters are not well understood.

Tachina flies are very easily overlooked, because they resemble large house-flies both in appearance and flight, and their presence out of doors is not usually noticed on that account. Yet they play a very important rôle, living as they do in their larval state entirely in insects. During the caterpillar plague such flies were often seen to dart repeatedly at an intended victim, buzz about it, and quickly disappear. If the caterpillar thus attacked was investigated, from 1 to 4 yellowish-white, ovoid, polished, and tough eggs would be found usually fastened upon its neck, or on some spot where they could not readily be removed. These eggs are glued so tightly to the skin of the caterpillar that they cannot easily be removed. Sometimes as many as 7 eggs could be counted upon a single caterpillar, showing a faulty instinct of the fly or flies, because the victim is not large enough to furnish food for so many voracious maggots. If the victim happens to be near a molt, it casts its skin with the eggs, and escapes a slow but sure death. But usually the eggs hatch so soon, that the small maggots have time to enter the body of the caterpillar, where they soon reach their full growth, after which they force their way through the skin and drop to the ground, into which they enter, to shrink into a brown, tunlike object (known technically as the coarctate pupa), which contains the true pupa. The caterpillar, tormented by enemies feeding within it, stops feeding, and wanders about for a long time until it dies. As a rule, not more than two maggots of this fly mature in their host, and generally but one. The caterpillar attacked by a Tachina fly is always either fully grown or nearly so.

Tachina flies abounded during the whole term of the prevalence of the caterpillars, but it is impossible to state positively whether they were all bred from them or not, since the many species of this genus of flies resemble each other so closely, that a very scrutinizing investigation would have been necessary to settle such a question. But there is no doubt that they were very numerous during the summer. Some maggots obtained from caterpillars kept for this purpose in breeding jars changed to flies in six days, others appeared in twenty-three days, and still others, obtained at about the same time, are still under ground, where they will hibernate. The maggots of these flies do not, however, always enter the ground, as some were found inside cocoons made by caterpillars among rubbish above ground.

REMEDIES.

Pruning and Burning.—The old and well-tried remedies of pruning or burning, or pruning and burning, will answer every purpose against this insect in ordinary seasons, where it is thoroughly done and over a whole neighborhood. It must, however, be done upon the first appearance of the webs on the trees, and not, as was done by the Parking Commission of this city last season, after the first brood of worms had attained their full growth and many had already transformed to pupæ. The nests at that time had assumed large proportions, and their removal entire injured the appearance of many young trees. Then, too, they were piled upon an open wagon, which was dragged for many hours around the streets, permitting a large proportion of the worms to escape.

On the first appearance of the webs, which should be looked for

with care, they should be cut off or burned off; and if cut off, they should be burned at once. The "tree-pruners," manufactured for the trade and well known to all gardeners, answer the purpose admirably.

The customary method of burning the nests is by means of rags saturated with kerosene or coal tar and fastened to the tip of a long pole. An old sponge has been substituted to advantage for the rags, but probably the best substitute for this purpose is a piece of porous brick. In a pointed communication published in the *Evening Star* of August 21, Major Key, agent of the Humane Society, thus describes the making of a "brick-torch:" "Take a piece of soft brick, commonly termed salmon brick, trim it to an egg shape; then take two soft wires, cross them over this brick, wrapping them together around the opposite side so as to firmly secure it; now tie this end to a long stick, such as the boys get at the planing-mills, by wrapping around it; then soak the brick in coal-oil, light it with a match, and you are armed with the best and cheapest weapon known to science. Holding this brick torch under the nests of caterpillars will precipitate to the sidewalk all the worms on one or two trees at least from one soaking of the brick, and it can be repeated as often as necessary. Then use a broom to roll them under it, and the work will be done, the controversy ended, and the trees saved."

A little thorough work with a simple torch like this, *at the right time*, will in nearly every case obviate the necessity of the more expensive remedies later in the season, when the worms of the first brood have grown larger, or when the second brood has appeared.

MULCHING.—After a bad caterpillar year a little judicious raking together of leaves and rubbish around the trunks of trees which have been infested, at the time when the worms of the second brood are about full-grown and before they commence to wander, will result in the confinement of a large proportion of the pupæ to these limited spaces, where, with a little hot water or a match, they can readily be destroyed during the winter. Many of the caterpillars of course reach the ground by dropping purposely or falling accidentally from the branches, but the great majority descend by the trunk, and finding the convenient shelter for pupation ready at the foot of the tree, go no farther. This has been tested on the Department grounds the past season, and is mentioned as a method of riddance supplementary only to others.

ARSENICAL POISONS.—It is seldom, however, that individuals, and still more rarely that corporations, can be brought to the use of remedies until damage is plain, and when this time comes nothing is better than the application of some one of the arsenical mixtures. We have already treated of the methods for applying such mixtures to shade trees on a large scale in our report as Entomologist to the Department for 1883, and in Bulletin 6 of this division, in both cases in connection with the treatment of the Imported Elm Leaf-beetle (*Galeruca xanthomelæna*).

The most economical and convenient apparatus consists of a large barrel, provided with a force-pump and mixer, mounted on an ordinary cart. A long hose, a metallic pipe, and a cyclone nozzle, arranged for elevation by means of a bamboo pole, complete the outfit.

Detailed descriptions of the apparatus having already appeared in the reports just mentioned, it is unnecessary to repeat them here.

A somewhat similar apparatus is used in the California orange groves against the Cottony Cushion-scale, and is illustrated in opera-

tion on Plate V. In this case a tank made especially for the purpose is mounted in the high wagon-box and secured by cleats, and supports a small hose-reel. The so-called "San José nozzle" (a direct-discharge nozzle) is used. A feature of the illustration is the long, portable ladder, which can be handled by one man. Such an apparatus as this would be well adapted for use against the Web-worm. It could be readily constructed and kept for years by the parking authorities of any city liable to the attacks of this or other leaf-eating shade-tree pests.

In the use of arsenical poisons a number of points were brought out by the series of experiments upon the Elm Leaf-beetle which are important, and which may be briefly adverted to here:

Certain trees are more susceptible to the corrosive effects of the arsenic than others. The 1883 experiments were confined to Elms, and we have no reliable data as to the relative susceptibility of other shade trees; so that we can simply mention the probability that those trees which are most liked by worms are more apt to be affected by the poison than trees which are distasteful to the worms.

"After each rain the poison takes a new effect upon the plant and the pest, which indicates that the poison is absorbed more or is more active when wet, and that it acts by dehydrating thereafter. Where the tree is too strongly poisoned each rain causes a new lot of leaves to become discolored by the poison or to fall. On some of the trees the discoloration appears in brown dead blotches on the foliage, chiefly about the gnawed places and margins, while in other instances many of the leaves turn yellow, and others fall without change of color. * * *

"The poison not only produces the local effects from contact with the parts touched by it, but following this there appears a more general effect, manifested in that all the foliage appears to lose, to some extent, its freshness and vitality. This secondary influence is probably from poisoning of the sap in a moderate degree. When this is once observable no leaf-eater thrives upon the foliage. Slight over-poisoning seems to have a tonic or invigorating effect on the trees."

In the case of the Elm Leaf-beetle it was found that a *preventive* application of the poison was valuable. It was made while the eggs were being deposited and before the young larvæ were hatched, in order to prevent the worms from getting a start. It had the additional advantage of injuring the tree less than when applied later in the season, as the caustic effect of the poison is greater when it comes in contact with the sap at the gnawed edges and surfaces of the leaves.

It was found advisable in 1883 to mix a certain amount of flour with the Paris green or London purple used, in order to render the mixture adhesive to the leaves. Three quarts of flour were used to the barrel (40 gallons) of water. Where London purple was used it was noted that the minimum amount per barrel of water was one-fourth of a pound and the maximum three-fourths of a pound. Less than the minimum did not kill the larvæ and more than the maximum injured the foliage. Three-eighths of a pound was recommended. With Paris green the quantity was somewhat greater, ranging from a minimum of one-half of a pound to a maximum of one pound.

In mixing the poison, flour and water, a large galvanized iron funnel of thirteen quarts capacity, having a cross septum of fine wire gauze, and having also vertical sides and a rim to keep it from rock-

ing on the barrel, was used. The flour was first placed in the funnel and washed through the wire gauze with water. This caused it to diffuse in the water without forming in lumps. The same process was followed with the London purple or the Paris green, according to which substance was to be used.

London purple has the advantage over Paris green in cheapness, better diffusibility, and visibility upon the foliage, and experience showed that the green seemed to injure the foliage more than the purple.

It was noticed with the Elm Leaf-beetle that the effect of a poisoning was slow in appearing; good effects are not expected before the third or fourth day. Impatience which would lead to a repoisoning on the second or third day would be apt to result in the burning and fall of the leaves.

EMULSIONS OF KEROSENE.—We have had occasion for the last few years to many times recommend the use of emulsions of kerosene against different injurious insects. We need not repeat the advantages of these preparations here, but simply state that when the Web-worms are abundant, a thorough spraying with a dilute emulsion will doubtless destroy the majority of them. On account of our absence last summer no experiments were made upon the effect of applying such an emulsion upon the foliage of the commoner shade trees, but the result of experiments detailed in Bulletin No. 11 of the Division would augur the destruction of the worms. These experiments (made by Mr. Webster at La Fayette, Ind.) were not performed upon this species, however, but upon the somewhat similar larvæ of *Pieris rapæ* and *Datana ministra*. Colonel Bowles, as we shall soon show, rejected the emulsion of soap and kerosene as not effective against the worms when reduced so as not to injure the plants; but, as he has not given us the details of the experiments, we still consider the matter open to proof. The formulæ for several emulsions are given in the article on the Cottony Cushion-scale (*Icerya purchasi*). One of the most serviceable is that which we call the "Hubbard formula," and which was used most extensively by Mr. Hubbard in his work on the scale insects of the Orange, and which has been repeatedly given in the publications of the Division.

NAPHTHA.—Some experiments were undertaken in the height of the Web-worm season by Col. John Bowles, of Washington, which possess a certain interest on account of the substance used and on account of the manner of its application. It is, however, more expensive than the arsenical poisons and the kerosene emulsions, and the spray from the atomizer is not so far-reaching as from the force-pump and cyclone nozzle. We append Colonel Bowles's condensed account of his experiments, with the remark that the experiments with the oil doubtless failed of satisfactory results because of imperfect emulsifying and application:

In accordance with your request I send herewith a concise statement of experiments made by myself in exterminating caterpillars, web-worms, &c., which destroy the beautiful foliage of our shade trees.

My experiment commenced with an effort to save the shrubbery of my yard and garden from the rapacious caterpillars that seem almost to germinate in the poplar trees, one of which stood in our front yard. After denuding this tree and literally raising an army of conquest and invasion, they broke camp and set forth as a huge foraging party, consuming everything in their way, save the rough bark of the trees and the fences.

I opposed them first with kerosene oil, which was equally fatal to the plants and worms.

Then a simple emulsion of soap in proportion of 1 to 4 was made with the oil and finally abandoned, not being effective against the worms when reduced so as not to injure the plants.

Lighter oils of the same character were resorted to and applied with a spray. This killed the vermin, yet injured the plant. Still lighter oils were used, but, when sprayed on, the foliage was materially injured. A vaporizer by means of compressed air was substituted for the spray, and with use of very light oil or naptha, known in commerce as 88, in half a second froze the worm and plant alike, with this difference, that in ten or fifteen minutes the vermin revived, but the tender leaves and twigs wilted and turned black as though struck by Jack Frost in January.

The grade of oil was reduced until the proper gravity of, say, 77 was found to kill the vermin and still leave the plant essentially unharmed.

The mechanical devices for vaporizing the oil and applying it to the upper branches of trees and shrubbery alike, as demonstrated to the Commissioners of the District some time since, and to which you kindly refer, have been since perfected, and so reduced in cost as to make the management easy by any common day laborer and the whole cost within the reach of all interested, whilst the oil costs less than 10 cents per gallon.

JOINT WORMS.

Order HYMENOPTERA; Family CHALCIDIDÆ.

THE COMMON JOINT WORM.

(*Isosoma hordei*, Harr.)

This old and well-known species has for the past few years been increasing in numbers and importance in certain sections of the country, while for a number of years previously it had been almost lost sight of. Since 1881 its work has been quite noticeable in portions of Louisa, Albemarle, Goochland, Orange, and Fluvanna Counties, Virginia, or, in other words, in just the locality where it was observed and studied thirty-five years ago by F. G. Ruffin, Professor Cabell, and Mr. Rives. Through the courtesy of Mr. F. C. Brooke, of Cuckoo, Louisa County, we have been kept informed of the progress of the pest and have been supplied with specimens from time to time.

In June, 1885, wishing to learn definitely the state of affairs in this section, and more particularly on Mr. Brooke's farm, we sent one of our assistants, Mr. Pergande, accompanied by Mr. A. Stewart, a member of the Entomological Society of Washington, to Cuckoo to make a few days' observations. The reports made by these gentlemen showed that the damage done to the wheat crop by this and other wheat insects was very great. Mr. Brooke's crop for 1884 averaged less than 5 bushels to the acre, which did not pay expenses.

The Joint Worm was not alone concerned in accomplishing this result, although an important factor. The Hessian Fly (*Cecidomyia destructor*), the Wheat Midge (*Diplosis tritici*), the Wheat Isosoma (*Isosoma tritici*), the Tarnished Plant-bug (*Lygus lineolaris*), and quite a number of other hemipterous insects were present in force, and almost every straw had been injured by one or more of these species. In the portions of the field most injured the plants were often scarcely a foot in height, few in number, and many were bent near the ground, so that frequently six or eight out of a bunch of twelve were prostrate. The ears of these straws were, however, better developed and fuller of sound grain than those which stood erect. On examination the prostrate stalks were found to be badly infested by Joint Worms above the first or second joint, but almost entirely free from Hessian Fly and Wheat Midge, while the standing stalks

frequently had both of the others in addition to *Isosma tritici* and *I. hordei*. Of all these the Wheat Midge undoubtedly did the greatest and most direct damage, and many ears were found white and blasted from its work. In the most flourishing parts of the field, where the stalks were green and 4 feet high, the Joint Worm was also found, although not in such numbers as before.

The larvæ of *Isosoma tritici* were often found in the same stalk with *I. hordei*, often boring just alongside of the galls of the latter. *I. hordei*, however, were quite uniformly found just above the first or second joint, and in such position that the cutting of the grain would not disturb them, while *I. tritici* was found in all parts of the stalk from near the ground to above the upper joint.

In spite of the great abundance of the Joint Worms at this time they were less numerous than in 1884, and in 1886 they were still more reduced in numbers, owing, in great measure, to the prevalence of Chalcid parasites in 1885. The most abundant of these was *Semiotellus chalcidiphagus* Walsh, the larvæ of which were found in nearly every swelling examined. The larvæ of *Eupelmus allynii* (French) were also found, but in smaller numbers.

A study of the comparative injury done by the four principal insects found in this field would rank them in the following order: *Diplosis tritici*, *Cecidomyia destructor*, *Isosoma tritici*, *Isosoma hordei*, yet *I. hordei* alone had been complained of.

In parts of Ohio, too, the Joint Worm has been abundant. Mr. Elliot Luse, of Barry, Cuyahoga County, writing under date of May 4, 1885, complained that the previous Fall, while threshing, bits of hard straw from half an inch to three inches in length would come through with the wheat. When cleaned with a hand-mill he would get a bushel of these bits to 20 bushels of grain. The real nature of the small pieces was not discovered by Mr. Luse until spring, when, after feeding stock with chopped straw and ground feed and making them sick, the straw was examined and the insects found and sent to us for determination.

This case formed the text for an article which we wrote for the *Rural New Yorker* of June 20, 1885 (vol. 44, p. 418), in which we pointed out the necessity of cleaning with a hand-mill all wheat thrashed with a steam-thrasher from infested straw, and of burning not only the galls thus separated, but also the straw itself, as its loss can be well afforded to lessen the injury the ensuing year.

Specimens were also received from Chagrin Falls, a few miles south from Barry, in October, 1885, from Miss E. J. Phillips, who stated that the wheat straw had been badly infested in that vicinity for two years past, but that the yield did not seem to have been affected, as she knew of several fields which yielded 30 and 35 bushels per acre, and which were at the same time badly infested. The only trouble was that the little pieces of straw came through the separator with the wheat.

In Central New York the Joint Worm has also done some damage, as we learn from correspondence with Dr. Lintner, the State entomologist. Here, as in Ohio, the worms were often found higher in the stalk than was customary in Virginia. In Ohio this is shown by the fact that so many galls were found in the harvested straw, while Dr. Lintner writes us that his correspondent informed him that the worms were found "in every joint." From this he argued that it might be *Isosoma tritici*, instead of *I. hordei*, but its identity with the latter species was settled by breeding the adults at the De-

partment from straws received from Dr. Lintner, who has referred to this matter publicly in the *Country Gentleman*, vol. 49, p. 857.*

In Michigan the same insect appeared in 1884, working in the same way. In the *Rural New Yorker* for May 9, 1885 (vol. 44, p. 314), Prof. A. J. Cook described it in all stages at some length under the name of "The Black Wheat-stalk Isosoma" (*Isosoma nigrum*, n. sp.). He stated that he had received it from Wayne and Washtenaw Counties, and that at a "farmers' institute" held at Plymouth, Wayne County, in January, he found hardly a farmer who had not been vexed by the small pieces of straw, but that not one had discovered the cause.

On the appearance of Professor Cook's article we wrote to him for specimens, strongly suspecting that his new species would turn out to be the Common Joint Worm. He kindly complied with our request, and our suspicions were at once verified, and, as stated in our article in the *Rural New Yorker* (*loc. cit.*), they proved to be well-marked examples of Fitch's *tritici* form of *I. hordei*. Professor Cook is still, we believe, inclined to insist that his species is a good one, but without going into the details of our rather extensive correspondence with him in this matter, we reassert the correctness of our conclusion and pronounce the Michigan insect to be *I. hordei*.†

In conclusion we may extract a few facts from our notes bearing on the dates of transformations and the prevalence and habits of the parasites:

December 9, 1884.—Eight straws which were received from Louisa County, Virginia, July 30, were examined, with the following result: No. 1. Two parasites had issued, and the straw still contained three pupæ of Isosoma and seven larvæ of a Chalcid parasite. No. 2. Five parasites had issued, and seven parasitic larvæ still remained. No. 3. Ten parasites had issued, and one pupa of Isosoma; one living and three dead larvæ of the parasite remained. No. 4. Two parasites had issued, and six pupæ of Isosoma, and one parasitic larva. No. 5. One parasite had issued, and three Isosoma pupæ and four parasitic larvæ remained. No. 6. Two parasites had issued, and three pupæ of Isosoma and two parasitic larvæ remained. No. 7. Contained four Isosoma pupæ and three parasitic larvæ. No. 8. Five Isosoma pupæ and five parasitic larvæ. Isosoma was found only in the pupa state.

On December 17 the adult Isosomas began to issue, and they continued to appear in small numbers through January, February, March, and April, issuing most abundantly the first week in May. On May 28 straws were received from Louisa County which contained eggs nearly ready to hatch.

The breeding of 1885–'86 was very similar to this, and indicates that the periods mentioned are about normal. The adults of both sexes

* In the *American Agriculturist* for December, 1884, vol. 43, p. 531, what is evidently the same insect is treated as having been received from "Central New York," and which is there determined as *Isosoma tritici*, a reproduction of our figure of that species being also given.

† Professor Cook later republished the bulk of his first article on the subject as an original contribution to the *American Naturalist* for September, 1885 (pp. 804–808). Here he seems to be in some doubt as to the validity of his species and expresses the opinion that it will take time to "clear all this up," and says: "As species are only venerable varieties which by age have been run into the mold of variability, it really makes no great difference. Practically the matter remains the same in either case." Such reasoning would justify unlimited species-making from any one species known to be quite variable.

began to issue in numbers from Virginia straws December 19. December 31 another large lot issued, as also on January 5, January 8, and February 1.

From our breedings it becomes doubtful whether the principal parasite of the Joint Worm (*Semiotellus chalcidiphagus*, Walsh) has one or two annual generations. A few specimens were swept in the field by Messrs. Pergande and Stewart as early as June 13, while in the Department breeding-jars they issued in large numbers through July and on until August 22. Then no more were noticed until October 10, when a number were found in the jars.* During the winter straws cut open showed the presence of many of these parasites still in the larval state. April 9 a large number issued, and none after this date.

From these facts it seems that this species winters both in the adult state and as larvæ in the straws, the latter issuing in early spring. They undoubtedly oviposit in growing grain infested with *Isosoma* in the spring, and some individuals develop and issue in July and August, while others winter in the straw and stubble as larvæ. What becomes of the adults which issue so early in the season we can only surmise. It is after harvest when they appear, and to parasitize Joint Worm larvæ they would have to pierce the hard stubble or work their way into their own holes of exit or into the cut ends of the stubble; not a very likely proceeding. These early individuals may oviposit in some other host, or they may live and hibernate without ovipositing before spring.

The common *Eupelmus allynii* (French) is also, as we have elsewhere stated,† a parasite of *Isosoma hordei*, as well as of *Isosoma tritici* and the Hessian Fly (*Cecidomyia destructor*). From the Joint Worm it has also been bred from Virginia specimens, and on three dates, viz, August 22, 1884, October 11, 1884, and April 9, 1885. Although a considerable number issued on each of these dates, it appears to be only about one-tenth as numerous as the *Semiotellus*.

THE WHEAT-STRAW ISOSOMA.

(*Isosoma tritici*,‡ Riley.)

In our annual report for 1884, in describing the larger Wheat-straw Isosoma, we called attention (p. 358) to the possible relationship between this species and *I. tritici* in the following words:

"It may be here stated as an interesting fact that of the specimens so far reared both of *tritici* and *grande*, all are females, and whether or not there is any dimorphic relationship between these two forms is a question which future observations alone can decide. The probabilities are, however, that there is no connection between them, for,

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*There is a possibility that some of these issued several days prior to this date.

† On the Parasites of the Hessian Fly, by C. V. Riley, Ph. D., Proceedings of the U. S. National Museum, 1885, pp. 413–422.

‡ As the object of this article is to show that the two species which we have described as *Isosoma tritici* and *I. grande* are in reality but seasonal dimorphic forms of one and the same species, it may be well to state that we retain the species name "*tritici*" as having priority, and because it represents the bisexual form of the species. We retain this name in preference to "*grande*" because, in addition to these reasons, it is an eminently appropriate name, and, as we have previously shown, Fitch's *Eurytoma tritici* is but a variety of *Isosoma hordei*, and cannot even be looked upon as entitled to a varietal name, since there is no constancy in the characters upon which it is based.

on the assumption that they represent alternate generations, we should expect the one or the other to comprise both sexes."

The history of our experiments with the two forms, in order to ascertain whether or not the relationship suggested in the above paragraph has any real existence, is briefly as follows:

Grande was first found by Mr. Webster in the summer of 1884. He observed it, and indeed bred it, early in June in Illinois, and on June 6 found females ovipositing in wheat at Oxford, Ind. On the 7th he found a pupa and a fully developed adult in wheat-stalks. The adults continued abundant until the 18th, when they began to decrease in numbers, and the last one was noticed June 27. A number of the straws in which these females were observed to oviposit in the field were sent to the Department, and a number were retained by Mr. Webster himself. From the straws sent to the Department *tritici* issued very abundantly in January and February, 1885. With Mr. Webster two premature individuals issued in October, 1884, and others issued in December, 1884, and January, and February, 1885; but all attempts to induce oviposition proved failures. No specimens of *grande* made their appearance. From straws left outdoors *tritici* issued in March and April, and again no specimens of *grande* were seen, although the straws were cut open and thoroughly examined.

This predisposed us to the conclusion that *tritici* had developed from eggs laid by *grande*, and although none of the specimens of *tritici* thus bred could be induced to oviposit in confinement, the hypothesis of an alternation of the two forms thus received strong support.

On the 2d of June, 1885, *grande* was once more observed in considerable numbers in a wheat plot, and examination showed this form present in nearly all stages of growth in the stalks. On August 12, 1885, stalks were isolated in which *grande* alone were observed to oviposit, and from these *tritici* began to issue at Washington January 7, 1886, and continued to issue on the following dates: January 15, 20, 21, 22, 23, 26, 27, and February 3, 4, 6, and 8, 1886. These all refused to oviposit, as was the case the previous winter. Mr. Webster was sent South the first of March on another investigation, and on his return to La Fayette in April found a limited number of *tritici*, which had emerged much later (probably during the latter part of March), still alive in his breeding-cages.

These specimens he at once transferred, as he states in his report, on the 12th of April, to young wheat plants grown and kept continuously under cover in a corner of his garden. These plants were carefully protected from outside insects, and on the 2d of June, 1886, the reverse of the former breeding was accomplished, and *grande* was bred from wheat in which indubitably nothing but *tritici* had oviposited! Several specimens issued in the next few days, and all immediately began to oviposit in the now nearly full-grown straw in other portions of the same stools from which they had issued.

The next step was then carried out, and these straws, in which the *bred* specimens of *grande* had oviposited from June 2 to June 12, were divided, and part sent to Washington and part retained at La Fayette, Ind., by Mr. Webster. On February 4, 1887, two female *tritici* were bred at Washington, and on the same day, as we subsequently learned, two were bred at La Fayette.

Thus the complete alternation of the two forms has been established. It will be remembered that the entire absence of a male among the many specimens of both forms bred and collected was a

stumbling-block to our acceptance of this hyphothesis in 1884 before the alternation had been proven, and it so remained until January 6, 1886, when a male Isosoma was bred by us from the same straws in which *grande* was observed ovipositing by Mr. Webster at La Fayette August 12, 1885, and which had since been isolated, and from which female *tritici* were being bred and were subsequently bred in numbers. On February 4 another of these males was bred from this lot of straw, and on February 6 still another, making three in all. In size these males were slightly smaller than the females of *tritici*, and of course much smaller than *grande*. They were all three fully winged, and could have been nothing else than the males of *tritici*. Attempts were made while they were yet alive to establish this beyond all peradventure by placing them with living females of *tritici* bred from the same straws and also with living females bred from straws received from California. The result was unsatisfactory. The males were lively and ran actively about in the breeding-jars, but made no attempt to pair. As soon as they came in contact with the females they either flew away or dropped as if startled. They were watched, however, only during the daytime from 9 a. m. until 4 p. m., and were in confinement in breeding-jars in the Divisional laboratory. All males died after three or four days, and none of the males issued on the same day with the females, so that one or the other was weak when watched with the opposite sex. It is also probable that the artificial conditions of a vivarium are unfavorable to proper development or maturity of the specimens, and that freedom and sunlight are essential to coition.

This breeding of the males, although not perfectly satisfactory, removes the last obstacle to the acceptance of the fact of alternation of generations with this species; for we must now call it a single species. The summary of its life-history in Indiana is as follows:

In March and April there issue from old last year's straws, either stubble or volunteer, wingless females of the *tritici* form, with, in some seasons, males. These oviposit in growing wheat. In June the winged females of the *grande* form issue from this same wheat, with, so far as known, *no* males. These oviposit in the now nearly grown straws of wheat, and from these eggs hatch larvæ which mature before winter and give forth adults of the *tritici* form early the ensuing spring.

From this summary it will be seen that it is the *grande* form alone which does the damage in Indiana; and supposing this relationship to hold wherever the species occurs, it effectually relieves those northern regions where only spring wheat is grown from any anticipation of injury, and indicates the obvious remedy of destruction of stubble and volunteer grain in the cultivation of winter wheat. In localities where both winter and spring wheat are grown we should expect to find the insect the most numerous.

Bearing out this suggestion, we may state that we have received the insect from no portion of the country in which spring wheat exclusively is grown.

We have used the above qualifying clause as to the alternation of generation in these two forms in all sections where the species occurs, for the reason that while *grande* has been found only in Bloomington and Normal, Ill., and Oxford and La Fayette, Ind., *tritici* has been sent to us from Virginia, Indiana, Illinois, Tennessee, Missouri, Kansas, California, and Washington Territory.

Mr. J. F. Donkin, of Grayson, Stanislaus County, California, wrote

us under date of May 23, 1885, sending specimens, and again on June 19. Mr. Coquillett, writing from Atwater, Merced County, California, June 29, sent similar specimens. Mr. Donkin, in his first letter, said: "They are killing a large percentage of our wheat. The heads turn yellow and die long before the wheat ripens." In his second letter he supplemented this as follows: "I send you by this mail samples of wheat-straw taken from different fields several miles apart. I am told by friends who have been growing wheat for years on the same land that the worms are in all the wheat this year. They have found it in the wheat of every field examined. There is a difference of opinion about the damage done by it. Some say that when we have plenty of rain and the wheat is thrifty it does no harm. One told me that he had noticed pieces of about one-eighth of an acre in extent where about one-eighth of the heads had no wheat. Last year was the first that I saw any myself."

That this insect has existed in California for a number of years there can be no doubt from the evidence of correspondents. It is probably the same insect which was sent to Dr. Packard through the *Pacific Rural Press* in September, 1879, from Healdsburg, Sonoma County, California, and which was identified by him as a wingless Joint Worm. Other specimens were received by him the same year from Madison, Yolo County. It was also received by us in September, 1882, from Mr. J. A. Starner, of Dayton, Columbia County, Washington Territory, in stalks which contained larvæ and pupæ. Although the work and early stages were precisely similar to those of *tritici*, the great difference in locality led to the presumption that it might be a different though related species, but subsequent breeding of the adults settled the question of identity.*

The presence of this insect in the other States mentioned has already been placed on record, with the exception of Kansas. From this State we received specimens in July, 1885, from Mr. Warren Knaus, of Salina. The straws contained larvæ which were dried up on receipt, so that it was impossible to say to which form they belonged. The work in the straws indicated either *tritici* or *grande*, while the date of collecting (July 5) rendered it more probable that they were *grande*. As this is the first recorded finding of *Isosoma* in Kansas, we may quote briefly from Mr. Knaus' account:

"I mail you to-day a box containing specimens of what I take to be *Isosoma tritici*. The joints infested are all the second from the ground, and are the only ones in the stalk of wheat containing the worm. Stalks from various fields are almost all infested, many containing three larvæ. I have taken a number of larvæ from immediately above the joint next the head. My observation is that these worms have caused more damage to the wheat in this part of the State than the Hessian Fly fully 50 per cent. of the heads in many fields of wheat showing their work in a very marked manner."

In a letter dated August 16 he gives the following:

"I have just returned from a trip through Northwest Kansas, and find that the Wheat-straw Worm has seriously damaged the wheat in the counties of Ottawa, Cloud, Osborne, Rooks, and Phillips; also in Saline, McPherson, and Dickinson Counties. It has really done more damaged than the Hessian Fly."

In order to compare the customary situation and abundance of the larvæ in the straw in California with Mr. Knaus' statement and with

*See *American Naturalist*, December, 1882, p. 1017.

Mr. Webster's table in our last Annual Report (p. 386), we give the result of an examination of ten straws received May 23 from Mr. Donkin, of Grayson, Cal.:

Above fourth knot from ear	3
Above third knot from ear	12
Above second knot from ear	15
Above first knot from ear	5
In second knot from ear	2
In third knot from ear	6
In fourth knot from ear	1
Total number of larvæ in ten stalks	44

PARASITES.—By far the most numerous parasite bred during the season from both the bisexual and unisexual forms has been *Eupelmus allynii* (French). But one specimen (female) of *Stictonotus isosomatis* Riley, which we described in our Annual Report for 1881–'82 (p. 186), has been reared since the original description, which was drawn up from one female and two males. We have, however, bred a most interesting parasite of the Proctotrupid genus *Dryinus* from the *grande* form and a new Pteromalid from both forms.

SILK CULTURE.

In our last Annual Report we reiterated the recommendations which we had several times made that means be given for the establishment in Washington of an experimental silk filature, and expressed the hope that we should be able to obtain a certain number of Serrell automatic reels with which to carry out any experiments which might be authorized.

In pursuance of this recommendation Congress, at its last session, appropriated $10,000 in aid of silk culture, and, among other things, authorized "experiments with automatic machinery for reeling silk from the cocoon at some point in the District of Columbia." The experimental reeling station at New Orleans had been closed at the beginning of the calendar year, and on the 30th of June that at Philadelphia was also closed and its appurtenances loaned to the Women's Silk Culture Association, in aid of which Congress also appropriated $5,000.

In pursuance of this act (June 30, 1886) an experimental silk filature has been set up in one of the Department buildings in Washington. It consists of a battery of six Serrell automatic reels and an automatic cocoon-brushing machine, invented partly by the same engineer.

Several objects will be held in view in operating this establishment. Among them we shall endeavor to settle conclusively the commercial value of Osage Orange as a silk-worm food, and, more important still, as foreshadowed in our last report, will be the determination of the question as to whether silk can be reeled with profit in the United States by means of the most improved machinery.

OSAGE ORANGE VS. MULBERRY.

In reference to the first object, the work already done justifies the statement that cocoons raised from Maclura-fed worms produce as good a silk as when the worms are fed on Mulberry. The difficulty found when these cocoons were reeled in France was that the rendi-

tion* was too great, being in the neighborhood of 5, while 4 is only a fair result with white-mulberry cocoons.

The second week's work in the Washington filature on Osage Orange cocoons gave a rendition of 3.69, and subsequently a result as low as 3.65 has been attained. This result was reported to Mr. Serrell, the inventor of the reels used, who, though living abroad, has always taken a lively interest in American silk culture, and his comments thereon are so encouraging that their substance is presented here:

The rendition from Osage Orange cocoons at the Washington filature is astonishing. So far as I know, the only time they have been reeled in France they gave a rendition of nearly 5. That is to say, as reeled in France it took a pound and a third more cocoons to produce a pound of silk than in the work done in Washington. It is fair to say, however, that in France they were reeled in a filature accustomed to only the best French cocoons.

"Be that as it may, the result attained is extremely remarkable, and makes me foresee a prompter outcome from American cocoons than I had supposed was possible.

Of the silk mentioned several skeins were taken to New York and submitted to the most rigorous tests at the Silk-conditioning Works in that city. It is needless to go into the details of the technical report made by its manager, but it will suffice to say that this Osage Orange silk gave excellent results, the faults being such as can be cured as our silk-raisers gain in experience.

The use of Osage Orange as a food-plant has now become quite general in the States where it is plentiful. Some observations which have been made on cocoons raised therefrom may be of service to the raisers who employ it. If two batches of cocoons be taken, raised from the same eggs, the one on the Mulberry and the other on the Osage, they will to the ordinary eye possess no distinct characteristics. The expert, however, can at once and almost unerringly designate the food used in either case, and this on account of the greater degree of satinage observable in those produced by the Osage Orange-fed worms. It was explained in the last edition of our manual that this satinage consisted of an inferior gumming together of the layers of the cocoon, and is made apparent to the eye by the coarser texture of its surface. As a result, the water penetrates to the interior, and causes them to sink to the bottom of the basin in reeling, and thus to break off the filament. Although this difficulty has not been proved to be the result of any given cause, still it is generally believed to be due to the insufficient feeding of the worm during the last days of its life. At this time almost all of its food goes to the formation of silk, and though a worm may make its cocoon if the feeding is stopped five days after the last molt, still it will be weak and commercially useless. In order that it should be strong and well garnished, no food should be spared at this time. The almost universal difference found between the cocoons raised on Osage Orange and Mulberry in this particular leads to the opinion that a greater quantity of the former food is required than of the latter, and that our people have not learned to supply their silk-worms with enough liberality during the days which precede the spinning.

What has been said above must not be construed as a serious objection to the use of such food, but simply as an indication of how it may be used with greater advantage than at present. On the con-

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*By "rendition" is meant the number of pounds of dry cocoons required to produce a pound of reeled silk.

trary, though nothing definite can be said as to the result of the limited experiments already made, the indications point to Osage Orange as at least the equal of Mulberry as silk-worm food, and confirm in continuous reeling the conclusions arrived at in previous years, and which we have reiterated in past writings.

THE SERRELL REEL—COST OF WORK UP TO THE PRESENT TIME.

In regard to the more important feature of our experiments we have not yet gone far enough to be willing to venture any opinion upon the probable outcome of the work. The limited appropriation prevented the setting up of more than six reels, though we had hoped to obtain twelve. Even with these six it has been somewhat slow work to train the young girls employed in their operation, and the consequent sale of the silk produced has been delayed longer than we anticipated. But at the best we cannot this year hope for results which will be more than indicative of the future prospects of the industry; for there are so many items of loss in the operation of a small establishment, which would not occur in a larger one worked under what we may call factory conditions, that it is impossible to make altogether accurate estimates. We shall be able, however, to show the silk manufacturers of the country what quality of silk can be made from American cocoons, and to give capitalists some indications of the probable profit to be realized or loss to be suffered in working a filature supplied with the best machines. We hope to be able to give in our next annual report the result of at least nine months of work under as favorable conditions as are possible with a small establishment.

The expenses of the operation of the experimental filature have been so far as follows:

	Per week.
1 forewoman	$8 65
5 operatives	23 08
Total	31 73

Or of each of the five reeling days, $6.35.

It has been found best to reel forty hours per week, and employ the time Saturday in sorting cocoons, so that the above sum ($6.35) includes the total expense for productive labor employed in making one day's product.

Only five of the reels have been in operation. The best product made on the five reels mentioned has been 850 grams per diem (1.87 pounds).

This silk has cost us:

For labor as above	$6 35
For cocoons	7 29
Total	13 64
The value of the product would be, at minimum figures (1.87 pounds of silk, at $5)	9 35
Waste	1 50
Total	10 85

This will show a daily loss of $2.79, or a loss of approximately $1.50 per pound of silk produced, not including interest on capital involved or cost of superintendence. It is not a very good showing,

and we quote Mr. Walker's conclusion as to the chances of improving it:

"I am of the opinion that saving can be made in the following ways: In the present machines the two threads of each basin are so dependent upon each other that when one thread breaks the reels of both threads stop. Judging from the result of carefully noted experiments within the past week, I am of the opinion that if these threads were made independently of each other the daily production would be increased by 125 grams without increase of the labor employed. Again, the two girls at the reels, owing to their slight experience, are unable to keep the threads sufficiently free from almost exhausted cocoons, and as a result bunches run up into the *croisure* and cause the rupture of the filament. By careful noting of the time lost by these breakages I found that it amounted to 29 per cent. of the working day. I put Mrs. Vaccarino in the place of the two girls, and by her superior ability in taking out exhausted cocoons she diminished the loss of time to slightly over 6 per cent. It is probable that with properly constructed *purgeurs* the ratio of time lost would be reduced as low as 10 per cent. And I am now experimenting with some devices which justify, I think, my hopes of arriving at such a result. If I do succeed, I shall, without increasing my labor, increase my production from 1.87 pounds to 2.37 pounds.

"This silk will require in its production:

For labor	$6 35
For cocoons	9 24
Total	15 59

"The product will be worth:

Silk	$11 85
Waste	2 00
Total	13 85

"This would reduce the daily loss to $1.74, or the loss per pound of silk produced to 74 cents."

THE DISTRIBUTION OF EGGS.

In 1885, as stated in our last report, a quantity of silk-worm eggs were purchased of American silk-raisers and 150 ounces were distributed to applicants in different parts of the country. The general result was so unsatisfactory as to prevent the repetition of the experiment. There were but few of the sellers who had the slightest idea of the care to be taken in egg production, and it has not been thought wise to continue the encouragement of this kind of work. There is, too, undoubtedly, evidence of the existence in the country of much "seed" of inferior races, and it is our aim to prevent the use of this as much as possible by the gratuitous distribution of choice qualities. In 1885 our distribution was confined to the class of races commonly called the large Milan, and the same policy will be followed in 1887. Silk-raisers who have had cause to be dissatisfied with their stock, either from failure in their education or from poor prices received for their product, will do well to apply to the Department for a new supply.

The reason for confining the distribution of eggs to the large Milan

races is one dictated by the necessities of the case. They have, as a rule, been submitted to the Pasteur microscopical selection, which is not true of Asiatic stock. This would have been of little importance some years ago, but now there is good evidence of the existence of the pebrine in Japan and China, and the only means of guarding against it is by avoiding the purchase of such material.

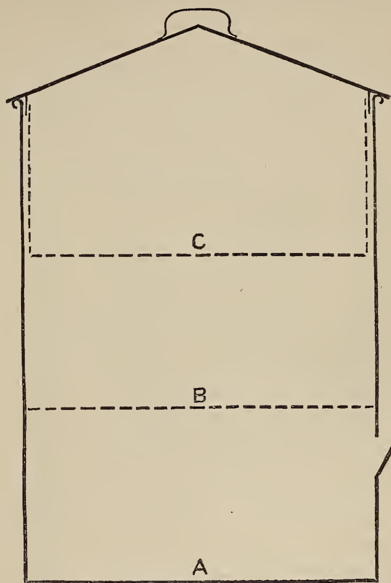
Of the Milan races, then, stock of assured purity may be obtained. The worms are hardy and the cocoons give excellent results in reeling. The few reeling establishments now existing or likely to exist in the United States in the near future can consume but a comparatively small quantity of cocoons and produce but a small quantity of silk. In order to find a ready market for such silk it must be of good quality, a term which includes among other things evenness of color. To produce this evenness we must have not only cocoons of the same color, but as much as possible of the same shade. The use of the many races now in vogue in this country prevents the attaining of this desirable end, and the cocoons that are offered at the filature are not all that can be desired in this direction. It is true that we might choose some of the other European races that are as carefully selected, such, for example, as the Bionne, but taking everything into consideration, the conditions sought for are best found in the large Milan varieties.

Last spring some of this sort of eggs, produced by the house of Darbrousse, in France, were sent to us by a gentleman in New Orleans, and a few of them were raised in the Department building, the food employed being Osage orange. There were almost no deaths in the batch, and about 4 pounds of cocoons were produced. It took 256 of these to make a pound, while 300 is considered an extremely good result. Part of the best of these were selected for reproduction, and were found to weigh a pound to each 216. Such cocoons as these are what silk-reelers want and are willing to pay extra prices for, but unfortunately there are few of them offered.

IMPROPER CHOKING OF COCOONS.

Our experience in the filature, too, has shown us that our people are sadly deficient in their knowledge of the art of stifling cocoons, and many lots have been received which were of otherwise excellent quality, but which had been burned by the employment of improper means for destroying the life of the chrysalis. It is the custom in Europe for the silk-raiser to dispose of his cocoons at the filature as soon as they are raised and before they have been stifled. The raiser then has the advantage of getting payment for his work as soon as it is completed, and the silk-reeler is enabled to stifle his cocoons in large quantities and by the most approved process. This scheme, however, has thus far been found impossible in the United States, as the silk-raisers are as a rule located so far from the available markets, that there would be danger of the moths piercing the cocoons before they could be choked. American buyers have therefore been obliged to purchase only stifled cocoons which have been thoroughly dried, and as this process of drying requires several months, silk-raisers have not received the proceeds of their season's labor until well into the autumn. And again, through inability to purchase apparatus or through lack of knowledge on the subject, they have resorted to such means of stifling as were at their command, and have destroyed in many cases an otherwise excellent crop. This burning of the cocoons

may always be obviated by using steam in their stifling and afterwards thoroughly drying them to prevent molding. A very efficient though simple piece of apparatus for thus stifling cocoons was purchased last spring by this Department of the New York Silk Exchange, and is within the means of most silk-growers. A sketch of it, in a slightly modified form, is given at Fig. 1. It consists of a tin reservoir, A, which, when in use, is about one-third filled with water. Slightly above the surface of the water is a movable perforated partition, B, intended to prevent spattering during ebullition. The uppe rportion contains a perforated pan for holding the cocoons, while all is tightly closed by a cover. Cocoons may be thoroughly stifled by exposure in this apparatus over boiling water for twenty minutes. It will be seen, too, that much the same apparatus can be contrived by the use of a deep kettle, into which is set an ordinary colander full of cocoons. It is well to avoid, however, so filling the kettle with water that it will splash upon the cocoons in boiling, as they should only be subjected to the action of steam. The apparatus owned by the Department is 12 inches in diameter and 13 inches deep, and will stifle from 3 to 4 pounds of cocoons at a time.



COCOONS PRODUCED IN THE UNITED STATES IN 1886.

Desirous of getting some statistics as to the amount of silk produced during the year in this country, and believing that the result could be approximately obtained by summing up the receipts at Washington and Philadelphia, we applied to Mrs. Lucas, who has kindly furnished the data from the Women's Silk-Culture Association of Philadelphia, of which she is president. These receipts are for the first half of the fiscal year, or from October 1, 1886, to the end of the year. They do not include whatever silk was raised in California, and will probably be materially increased by receipts during the first quarter of 1887. The result is, however, quite interesting, and the more so that no impetus was given to the raising of the cocoons by the establishment of the filature at Washington (and the same may be said in a great measure of Philadelphia), since the appropriation did not become available until after the silk-raising season was over.

Figures show that during the time stated there have been purchased at the Washington filature 1,313 pounds 15 ounces, valued at $1,272.04, and by the Women's Silk Culture Association at Philadelphia, 3,801 pounds 9 ounces, valued at $2,720.88. This makes a total of 5,115 pounds 8 ounces, for which there was paid the sum of $3,982.96, or nearly 78 cents per pound. These were obtained, as will be seen by the following table, from twenty-six States and Territories. It is probable that the table is not a just indication of the production

of those States, as there have been certain cases where lots of cocoons have been received at the filature which were the results of collections made from many different raisers and which were possibly not raised in the State from which they were purchased.

State.	Philadelphia.				Washington.				Total.				Average value per pound.
	Quantity.		Value.		Quantity.		Value.		Quantity.		Value.		
	Lbs.	*oz.*	*Dollars.*		*Lbs.*	*oz.*	*Dollars.*		*Lbs.*	*oz.*	*Dollars.*		*Dollars.*
Alabama	1	12	0	70	5	10	6	04	7	6	6	74	0 91
Arkansas	30	1½	15	40	5	1	3	54	35	2½	18	94	54
District of Columbia					3	12	3	32	3	12	3	32	885
Florida	56	2¼	52	24	8	2	4	05	64	4¼	56	29	88
Georgia	18	6½	11	38	0	12		78	19	2½	12	16	63
Illinois	780	2	622	33	249	7	241	12	1,029	9	863	45	838
Indiana	140	13	100	80	85	8	81	70	226	5	182	50	805
Iowa	165	2	111	68	3	2	3	59	168	4	115	27	685
Kansas	596	7	351	85	57	5	61	08	653	12	412	93	63
Kentucky	67	10	38	80	5	12	6	11	73	6	44	91	61
Louisiana	9	6¼	8	72	162	8	172	54	171	14¼	181	26	89
Massachusetts	4	6	3	41					4	6	3	45	788
Michigan	241	12	223	18	4	12	5	46	246	8	228	64	92
Mississippi	3	10	1	27	111	2	86	49	114	12	87	76	76
Missouri	267	13	194	45	125	12	129	04	393	9	323	49	82
Nebraska	71	3	32	18	116	11	125	78	187	14	157	96	84
New Jersey	8	8½	8	14	3	4	3	25	11	12½	11	39	966
New York	3	5	2	81	3	3	2	86	6	8	5	67	87
North Carolina	95	7	49	36	37	3	41	23	132	10	90	59	68
Ohio	1,063	11	780	13	121	5	113	13	1,185	0	893	26	75
Pennsylvania	54	4¼	40	55	144	4	115	40	198	8¼	155	95	78
South Carolina	9	4	4	77					9	4	4	77	515
Tennessee	37	0	13	56	2	3	2	18	39	3	15	74	40
Texas	11	12½	6	99	40	10	39	97	52	6½	46	96	89
Virginia	60	10½	42	80	15	4	11	95	75	14½	54	75	72
West Virginia	3	0	3	38	1	7	1	43	4	7	4	81	1 08
Total	3,801	9¼	2,720	88	1,313	15	1,262	04	5,115	8¼	3,982	96	772

REPORTS OF AGENTS.

REPORT ON REMEDIES FOR THE COTTONY CUSHION-SCALE.

By D. W. Coquillett, *Special Agent.*

LETTER OF TRANSMITTAL.

SIR: The following pages comprise my report upon the experiments to destroy the Cottony Cushion-scale (*Icerya purchasi*, Maskell).

In accordance with your letter of instruction I proceeded to Los Angeles on the 9th of February, 1886, and had a conference with the County Horticultural Commission relative to the best place for me to to locate in order to study to the best advantage the life-history and habits of the Cottony Cushion-scale, and they assured me that they could find such a location in the city of Los Angeles, but wanted time to enable them to make the necessary arrangements. Accordingly I returned to Anaheim, and on the 15th of February again visited Los Angeles, and was shown several orchards, in either of which I could carry on my investigations. I chose the Wolfskill orchard as offering the best opportunities for my studies, and was not a little influenced in my choice by the fact that I would thereby secure the aid of the superintendent of this orchard, Mr. Alexander Craw, whom I found to be a most careful and accurate observer of the habits of insects in general, and who has had considerable experience in combating scale insects of various kinds.

In this orchard I carried on my experiments with various remedies for the destruction of the Cottony Cushion-scale, and it was here that the greater number of my observations upon the history and habits of this insect were made; but I also studied it in many of the other orchards and yards in various parts of this city.

On the 18th of June, 1885, the board of supervisors of Los Angeles County passed an ordinance relating to the destruction of insect pests. In accordance with this ordinance the office of County Board of Horticultural Commissioners was established, and Messrs. J. R. Dobbins, George Rice, and S. McKinley were appointed to

the board. It is the duty of this commission to divide the county into districts and appoint an inspector for each district. When trees or plants are found to be infested with the Cottony Cushion-scale or other injurious insect the owner is notified of this fact and is requested to disinfect such trees or plants, and if he fails to do so within due time his premises are deemed a public nuisance, to be proceeded against as any ordinary nuisance until abated.

On the 4th of August, 1885, the city council of the city of Los Angeles passed an ordinance declaring trees and plants infested with the Cottony Cushion-scale within the city limits a public nuisance immediately, and it also established the offices of inspectors of fruit pests, whose duty it was to see that the provisions of this ordinance were enforced.

On the 13th of November, 1885, the board of supervisors of Los Angeles County offered a reward of $1,000 for a perfect exterminator of the Cottony Cushion-scale, and the horticultural commission and myself were appointed by the board to act as a committee for determining the efficacy of the various remedies presented by the different applicants for the above reward. Up to the present writing there have been eleven applicants for this reward, and these have made thirty-eight tests, but none of these remedies have been deemed worthy of the offered reward.

In the prosecution of my studies I have been not a little aided by the above commission and their able corps of inspectors, to all of whom my warmest thanks are due. Mr. Albert Koebele, one of the agents of the United States Division of Entomology, has been with me part of the time, and has aided me much in the mechanical part of my experiments.

Respectfully, yours,

D. W. COQUILLETT.

Prof. C. V. RILEY,
United States Entomologist.

GENERAL CONSIDERATIONS.

The great desideratum in a remedy for scale insects is that it shall kill all of the insects and their eggs without producing any injury whatever to the tree or fruit, and to this must be added the additional qualification that it must be reasonably cheap. A wash costing from 1 to 1½ cents per gallon would be cheap enough to be extensively used, while if it should exceed 3 cents per gallon it would be beyond the reach of the majority of the fruit-growers.

It is no difficult task to discover a wash possessing any two of the above qualities; but to discover one which possesses the three properties combined is a far more difficult matter.

The remedies in common use in Southern California for the destruction of the Cottony Cushion-scale consist of various liquid solutions applied to the infested trees in the form of a spray. The usual appliances for performing this operation consist of a force or spraying pump mounted upon a barrel or tank; to the pump is attached from one to four pieces of rubber hose from 15 to 20 feet in length, and to the end of each is attached an iron tube measuring from 4 to 10 feet in length. The nozzle commonly used is known as the "San José" nozzle, and is fastened to the outer end of the iron tube above described.

This nozzle consists of a short brass tube, upon the outer end of which is screwed a brass cap having a large opening in the top. This cap holds in place a circular piece of brass, in the center of which is a small slit, through which the solution is forced in the form of a fan-shaped spray. Sometimes a piece of rubber is substituted for the circular piece of brass in the nozzle; it has the advantage of not becoming clogged so easily as the brass one, but is far less durable.

The Cyclone nozzle, which has been fully described in previous reports of this Department, has been used by a few different persons here, but these, with one accord, prefer the San José nozzle. For thorough work, however, the Cyclone nozzle is to be preferred, as it does not become clogged so easily as the San José nozzle, and it also permits the operator to spray the leaves from all directions, the spray issuing from the side of the nozzle instead of from the outer end, so that by simply turning about the iron tube carrying the nozzle the spray can be thrown in all directions.

This defect in the San José nozzle is overcome to a certain extent by means of a ladder, by the use of which the tree can be sprayed both from above and from below. For this purpose an improved ladder, mounted upon wheels, is now coming into use. This can be wheeled from one tree to the other, and being provided with the proper supports, does not rest against the tree itself. In this way the operator can move up and down the ladder without being hindered by the branches of the tree he is operating upon. (See Plate V.)

Even the most skillful operator, however, when equipped with the best of appli-

ances, will find it to be absolutely impossible to spray the solution upon *every* insect on the tree, as a few are quite certain to escape, protected, it may be, by a curled leaf or similar object. Much can be done to aid in properly spraying the trees by first removing from the tree, especially from the inside of the top of it, all of the branches that can possibly be spared. This will not only greatly expedite the task of spraying and make it more efficient, but will make a great saving in the quantity of the solution required, thus lessening the cost of spraying in proportion to the number of branches removed.

Another item of importance is to prevent the great waste of that portion of the solution which ordinarily falls upon the ground after having been sprayed upon the trees. This can be accomplished by using some simple contrivance for catching the solution in such a manner that it can be made to flow into a tub or other vessel, being in the mean time strained from all extraneous substances; it can then be emptied into the tank or barrel to which the spraying-pump is attached and thus be used over again. It has been ascertained that fully *two-thirds* of the quantity of the solution first used could in this way be saved and with but very little additional labor.*

As illustrating the extreme tenacity of life with which the female Cottony Cushion-scale insect is endowed, I may state a fact that I have frequently witnessed, namely, that an adult female, with her egg-case attached, when sprayed with a solution so caustic that her back was burned black and was hard and wrinkled, still retained the use of all of her organs three weeks after the application of the solution had been made. In such instances the cottony egg-sac had been hardened and discolored by the solution, and the addition to it which the female had excreted after the application of the solution was very conspicuous by its whiteness.

Several persons have succeeded in clearing their trees of the Cottony Cushion-scale by simply spraying them with pure cold water thrown upon the trees with considerable force, repeating the operation once or twice each week until all of the insects have been removed from the trees.

When once these insects have inserted their beaks into the bark of the tree it is quite impossible to extract them from the bark by any forcible means that we may employ, as the beak is very brittle and easily broken off short to the body. It is doubtless owing to this fact that the water remedy referred to above is so effective when employed against these insects, as the beaks are broken off in dislodging them from the tree, and the insects, thus deprived of the organ through which their food is obtained, must necessarily perish of starvation.

This method is practicable only in places where but few trees are to be treated; it is much too laborious and requires repetition too frequently to be used on a large scale.

Following is a summary of the experiments which I have made with various remedies for the destruction of the Cottony Cushion-scale. For spraying these solutions upon the trees I used a Johnson pump and a Cyclone nozzle.

In making these experiments it has been my aim to discover a remedy that would prove fatal not only to the insects in their various stages of development but also to the eggs, as it will be easily seen that if the latter are not destroyed they will in due time hatch out, and thus again stock the tree with these pernicious pests.

Of course a remedy that merely destroys the insects could be used with good success by making a second application at an interval of about two months after the first one, thus giving the eggs time to hatch out; but this would require double the labor and cost of a single application and the risk of injuring the tree would also be much greater.

CAUSTIC POTASH.

The crude potash was dissolved in water and the solution then sprayed upon the trees. The cost of the potash at wholesale is about 7 cents per pound.

One Pound of Potash dissolved in one Gallon of Water.—An hour after the application the leaves upon the newest growth on the tree had sensibly withered; nine days later about one-half of the leaves had dried up and fallen from the tree. Two months after making the application one-tenth of the smaller lateral branches had become dead and dry, while upon the other branches a new growth had started. About 95 per cent. of the insects and 60 per cent. of the eggs were killed; the insects which es-

*Such a drain-table has already been made and used at San José for the purpose indicated. It is described in the first report of the State Board of Horticultural Commissioners, 1882, p. 83, in Mr. Chapin's report, as follows: "The table is made of sheet-iron and zinc, fixed upon a frame in halves, which are placed against the trunk of the tree on either side, thus forming a circular basin 14 feet in diameter, and requiring but one minute for transfer from one tree to another. * * * The saving caused by this was at least two-thirds of the material."

caped injury were those in the adult stage, both before and after excreting the egg-mass.

One Pound of Potash and two Gallons of Water.—This killed about one-tenth of the leaves upon the tree and several of the smaller branches. All of the insects in the first and second stages were killed, but only about one-half of the adult females, one-fourth of the females with egg-masses, and one-tenth of the eggs were killed.

One Pound of Potash and four Gallons of Water.—This killed about 5 per cent. of the leaves and burned brown spots of various sizes in many of the others. Nearly all of the insects in the first and second stages were killed, but not more than one-fourth of the adult females before secreting the egg-masses were killed, while the females with these egg-masses were scarcely affected by the application; eggs uninjured.

CAUSTIC SODA.

The crude caustic soda was used; the present price of the soda is 5 cents per pound when purchased in large quantities.

One Pound of caustic Soda dissolved in two Gallons of Water.—This killed all of the leaves upon the tree and burned the bark brown, but later in the season the tree put forth a new growth on some of the larger branches. All of the insects were killed, with the exception of about one-tenth of the adult females before secreting the egg-masses and one-eighth of those with egg-masses; eggs scarcely injured. (In one of the egg-masses situated upon a spot where the bark had been burned brown I found three recently hatched larvæ five days after making the application.)

One Pound of caustic Soda to four Gallons of Water.—This killed about four-fifths of the leaves and one-third of the smaller branches, and burned the bark brown in large spots. With the exception of about one-sixth of the adult females before secreting the egg-masses and one-fourth of those with egg-masses, all of the insects were killed; eggs uninjured.

One Pound of caustic Soda to six Gallons of Water.—This killed about one-third of the leaves upon the tree, while the bark was not injured. A slightly larger number of the adult females escaped injury than in the preceding experiment; eggs uninjured.

Several egg-masses were immersed in a solution composed of 1 pound of caustic soda dissolved in 1 gallon of water; this killed about one-third of the eggs thus treated.

HARD SOAP.

This was a brown laundry soap, manufactured by the Los Angeles Soap Company, under the name of "Our Favorite German Chemical Soap," and I am informed by one of the members of the above firm that this soap is composed of tallow, caustic soda, a little sal-soda, and resin. It is retailed at the rate of 5 cents per bar, weighing somewhat less than a pound, but it could probably be obtained at wholesale at the rate of 3 cents per pound. It was first dissolved in hot water and afterward diluted with cold water, and sprayed upon the trees when quite cold.

One Pound of Soap and two Gallons of Water.—This left a whitish coating upon the leaves and bark of the tree, but did not appear to injure the latter. It killed all of the insects with the exception of about 1 per cent. of the females with egg-masses, and hardened the outside of the egg-masses to such a degree that the insects after hatching were unable to make their way to the outside world. Fully four-fifths of the eggs were thus virtually destroyed.

One Pound of Soap and three Gallons of Water.—This also left a whitish coating upon the leaves and bark. All of the insects were killed with the exception of about 4 per cent. of the adult females, before secreting the egg-masses and 8 per cent. of the females with egg-masses. About three-fourths of the eggs were destroyed in the manner related above.

Several of the egg-masses were immersed in a solution composed of 1 pound of the soap to 1 gallon of water, and not a living insect issued from either of the egg-masses thus treated.

It is necessary to spray these solutions when quite hot, since the cold solutions are of such a thick consistency that it is very difficult to force them through a spraying nozzle.

SOFT SOAP.

This was made by dissolving 1 pound of refined potash and 1 of concentrated lye in 3 gallons of water, to which was added one-half gallon of fish-oil. This was boiled for about one hour, when $4\frac{1}{2}$ gallons of water were added. The cost of these materials when purchased in large quantities is about as follows: Potash and con-

centrated lye, each about 10 cents per pound; fish-oil, 35 cents per gallon. The materials used in making the soap above described made about 66 pints of soap, at a cost of 37 cents, being a trifle over half a cent per pint.

Two Pints of Soap in one Gallon of Water.—This proved fatal to all of the insects with the exception of about 10 per cent. of the adult females. About three-fourths of the eggs were destroyed, the solution having the property of hardening the egg-masses.

One Pint of Soap in one Gallon of Water.—This proved fatal to all of the insects with the exception of about one-third of the adult females, but not more than one-third of the eggs were destroyed.

KEROSENE EMULSIONS

An emulsion was made by dissolving half a pound of hard soap in 1 gallon of water, and adding it, boiling hot, to 2 gallons of the best grade of kerosene (150° fire-test), and forcing this through a spraying-pump back again into the vessel containing the solution. This was continued for about twenty minutes, when a very good emulsion was formed.

This emulsion was used in various proportions from 1 part of the emulsion to 6 parts of water, to 1 part of the emulsion to 18 of water. Neither of these solutions produced an injurious effect upon the trees operated upon.

One Part of the Emulsion to six Parts of Water.—This proved fatal to all of the insects with the exception of about 6 per cent. of the females before secreting the egg-masses and 10 per cent. of those with egg-masses. Nearly all of the eggs were killed.

One Part of the Emulsion to nine Parts of Water.—This was fatal to only about one-third of the adult females and a somewhat larger proportion of the young ones. About four-fifths of the eggs were destroyed.

A number of the egg-masses were immersed in the undiluted emulsion, and none of the eggs thus treated hatched out.

An emulsion of the same grade of kerosene as that used above was formed of 2 gallons of kerosene and 1 gallon of sweet milk. This formed a better and more stable emulsion than the one made with soap-suds, but its effects upon the insects were not as good as those produced by the latter emulsion.

A solution composed of 1 part of this emulsion to 6 parts of water killed nearly all of the young insects, but proved fatal to only 10 per cent. of the adult females with egg-masses. About one-half of the eggs were killed.

A third emulsion was formed by emulsifying 2 gallons of the same grade of kerosene as that used above with 1 gallon of soft soap dissolved in 2 gallons of water. Considerable difficulty was experienced in forming a stable emulsion with these ingredients.

This emulsion was diluted with water to such an extent that each 5 gallons of the diluted wash contained 1 gallon of kerosene. This proved fatal alike to the insects in all of their stages and also to their eggs.

It was also used in such proportions that each 7 gallons of the diluted wash contained 1 gallon of kerosene; this was fatal to all of the insects with the exception of a small number of the adult females with egg-masses; all of the eggs were killed.

Even the strongest solution, containing 1 gallon of kerosene in each 5 gallons of the diluted solution, produced no injurious effect either upon the trees or fruit; the trees experimented on were small orange trees about four years old.

Unlike the soap solutions, which penetrate the egg-masses and afterward harden, thus preventing the escape of the young insects after hatching out, the kerosene deprives the eggs of their vitality by penetrating first the egg-sacs and then the eggs themselves.

The cost of the kerosene (150°) is about 20 cents per gallon when purchased in large quantities.

TOBACCO.

Two pounds of tobacco leaves and stems were boiled in water until the strength of the tobacco had been extracted; the solution when cold was diluted with water and used in various proportions.

When used in the proportion of 1 pound of the tobacco to each 2 gallons of water, all of the insects were killed; about 3 per cent. of the eggs escaped injury.

When used in the proportion of 1 pound of the tobacco to each 4 gallons of the solution, it proved fatal to all of the insects with the exception of about 10 per cent. of the adult females with egg-masses; about 95 per cent. of the eggs were killed.

The strongest solution used, 1 pound of tobacco to each 2 gallons of water, produced no injurious effect upon the tree.

Several egg-masses were immersed in a solution containing a pound of tobacco to

1½ gallons of water, and this proved fatal to about one-half of the eggs. As this is out of all proportion as compared with the other experiments made by spraying the egg-masses upon the trees with the tobacco decoction of various strengths, I am led to believe that when the egg-masses are simply immersed in any solution, except when held in the solution for some time, they do not become so thoroughly saturated with it as when the latter is sprayed upon them; and I have proved beyond a doubt that a solution thrown upon the insects in the form of a fine spray will have a better effect than if thrown upon them in a coarser spray, just as a heavy fog or mist will more thoroughly wet a tree than a heavy shower of rain in large drops will do.

The cost of the tobacco at wholesale is about 10 cents per pound, but sometimes refuse tobacco can be obtained from cigar manufactories at from 1½ to 2 cents per pound.

SHEEP DIP.

This was the "Gold-leaf" brand, manufactured at Louisville, Ky., and said to be a pure extract of tobacco; it costs about $1.75 per gallon when purchased in large quantities.

It was diluted with water in various proportions, but even when used in the proportion of 1 gallon of the dip to 30 gallons of water it proved fatal to only about four-fifths of the young insects and one-fourth of the adult females with egg-masses, while the eggs were scarcely affected by it.

Several egg-masses were immersed in the pure dip, and none of the eggs thus treated hatched out.

TOBACCO SOAP.

Samples of this soap were received from the manufacturers, the Rose Manufacturing Company, of 17 South William street, New York City. The soap was first dissolved in hot water and afterward diluted with cold water.

One Pound of the Soap to nine Gallons of Water.—This proved fatal alike to the insects in all stages of development and also to their eggs.

One Pound of the Soap to twenty-one Gallons of Water.—This was fatal to all of the insects with the exception of about one-third of the adult females before secreting the egg-masses and a slightly larger number of those with egg-masses.

The cost of this soap has heretofore been 50 cents per pound, but I am informed by the agent here, Mr. J. B. Francisco, that the price of the soap has been recently reduced one-half.

VINEGAR.

A small branch of a lemon tree upon which were a number of Cottony Cushion-scales was immersed in pure grape vinegar, but it had very little effect upon the adult females and their eggs, and produced no perceptible injury to the leaves. It likewise had but little effect upon the insects when used in the proportion of 1 gallon of vinegar to 8 gallons of water in which 4 pints of soft soap had been dissolved.

PARIS GREEN.

One-half an Ounce of Paris green was thoroughly stirred into two Gallons of Water.—The whole was sprayed upon a small orange tree growing in the shade of some large eucalyptus trees. This proved alike fatal to the insects and the tree. In many places upon the tree the sap had exuded from the bark in considerable quantities, and remained adhering to the bark in the form of a brownish gum.

One-third of an Ounce of Paris green to two Gallons of Water.—This was sprayed upon all parts of a small orange tree, the greater part of it being sprayed upon the trunk and bases of the larger branches. In these places all of the insects were killed, but fully one-third of those situated upon the outer ends of the branches were not killed. In several different places the sap had exuded from some of the branches.

One-fourth of an Ounce of Paris green to two Gallons of Water.—This also killed all of the insects upon the trunk and bases of the larger branches, where the greater part of the solution had been sprayed, but only about one-half of the insects situated upon the outer ends of the branches were killed. This solution did not cause the sap to exude from any part of the tree.

One-fourth of an Ounce of Paris green to two Gallons of Water and one Pint of the Kerosene Emulsion.—The emulsion was formed by emulsifying 2 gallons of kerosene in 1 gallon of hot water in which had been dissolved half a pound of soap. A pint of this emulsion was diluted with 2 gallons of water, after which the Paris green was added; but it was impossible to keep the green incorporated in the solution, as it would rise to the surface the moment the stirring ceased. The effect of the solution upon the tree and insect was about the same as in the preceding experiment, with the exception that only about one-third of the insects situated upon the outer ends of the branches were killed.

REPORT UPON SUPPLEMENTARY EXPERIMENTS ON THE COTTONY CUSHION-SCALE; FOLLOWED BY A REPORT ON EXPERIMENTS ON THE RED SCALE.

By Albert Koebele, *Special Agent.*

LETTER OF TRANSMITTAL.

Alameda, Cal., *December* 1, 1886.

Sir: I herewith submit a report of continued experiments on the Cottony Cushion-scale (*Icerya purchasi*), made at Los Angeles, Cal., after the expiration of the appointment of D. W. Coquillett, with whom I worked previously, as directed by you in letter of January 28.

My warmest thanks are due to Mr. August Buschhaupt, of the Los Angeles Soap Company, for kindly assisting me in preparing the various soaps.

Very respectfully,

ALBERT KOEBELE.

Prof. C. V. Riley,
U. S. Entomologist, Washington, D. C.

INTRODUCTORY.

The chief object of my work has been to find a wash as low in price as possible, and at the same time one which all the fruit-growers can prepare themselves. This, as is shown below, is not a difficult matter.

In March and April, while at work with Mr. Coquillett, and after witnessing various experiments, especially with soaps, I concluded that these, if tried in all their varieties, would prove good agents in destroying the scales, and that they also could be produced at a very reasonable cost. Up to this day, in my limited intercourse with orange-growers, I have seen nothing cheaper for killing the Cottony Cushion-scale.

It has always been a difficult matter to know just how much of the article used should be taken to a certain quantity of water to be effective on the scales and not injure the trees. Very often the spraying is done by inexperienced hands, and in such cases no good results can ever be expected even with the best washes. Naturally it will be used in stronger doses at the next operation, and the consequence will often be that there is more injury done than good. Experienced hands should always be engaged in this work to secure good results. I have myself witnessed a pair of inexpert operators, and was much amazed at the rapid progress of the work; yet when examining the trees a week later it was hard to find "dead scales."

No wash will be effective on *Icerya* unless penetrating the cottony mass, and for this purpose I found soap, or washes of soapy nature, the best. In most cases the majority of the young scales are found among the egg-masses, and unless these are destroyed the labor is of little value.

SOAP SOLUTIONS.

Almost any soap, if used in right quantity, will be destructive to both the eggs and the insects of *Icerya*, and, aside from resin compounds, will best penetrate the cottony mass. The egg-masses should always, and immediately after the tree has been sprayed, be completely penetrated by the wash. Unless this is the case the wash has not the effect of destroying everything. In some of the washes used, especially such as contained resin, the egg-masses, if not reached in the center, became so hard that rarely one of the young scales was able to leave its place of birth. Often one or more newly hatched scales will be found under the body of the mother scale at the point where the beak is inserted. Here, too, the mother scale exudes a little of the cottony substance, on which the body rests close to the bark. After light spraying and with weak wash this place remains dry and the young scales uninjured. Therefore a strong spray is of value, by which the scale is raised or somewhat removed from its firm place. Soaps 144 and 152, which I have made, will do as well at $\frac{1}{4}$ cent with a strong and thorough spraying as at $\frac{1}{2}$ cent by weak spray. Never have I observed eggs that were completely wetted by any of the washes used to hatch; in every instance they were destroyed.

For applying solutions there is nothing better than a cyclone nozzle for thorough work, especially if the exit hole be made considerably larger, to save time, and this is easily done.

The cyclone nozzle used in my experiments had been eaten out opposite the exit

hole to a depth of about 6^{mm}, and three additional plates of 2^{mm} thickness had been put on successively; a circular cavity formed in the chamber, and last the cap containing the outlet fell off. This also had been eaten nearly through. Not more than 1,000 gallons of wash had been sprayed with the nozzle. This may be largely due to the impure and sandy water used.

PREPARATION OF SOAP.

At the beginning of my work, in preparing whale-oil soap, I used chiefly Babbitt's potash or lye, which is sold in boxes of 4 dozen 1-pound cans, at from 9 to 10 cents per pound. To 1 pound of potash 2 gallons of water were added and placed over fire. After all the potash had been dissolved, 2 pints of fish-oil were added and contents cooked until the soap had formed; then 2 gallons more water were added and well mixed together. This formed a soft soap, and would, after cooling, readily mix with cold water.

The cost of this soap is about ½ cent per pint, and 2 pints are required to 1 gallon of water to destroy eggs and insects of *Icerya*. This would be 1 cent for 10 pints of wash. Fish-oil is sold generally at Los Angeles at about 32 cents per gallon, wholesale price.

Later, however, instead of using Babbitt's potash, I obtained caustic soda from the Los Angeles Soap Company. This is sold at wholesale by the same firm at 5 cents per pound, and it is equally as good as Babbitt's potash. To 1 pound of this caustic soda 3 pounds of grease, or part of that and resin to the full amount, should be taken, as will be shown in the experiments. Three pounds of tallow and resin to 1 pound of soda did much better work than did 4 of the first to 1 of the last. Tallow is sold by the same firm at 3 cents per pound and resin at 1½ cents, wholesale price. Almost any grease would answer in making soap, and much could be saved for this purpose which otherwise would not be made use of.

In making soap 152, 1 pound of caustic soda is dissolved in 1½ gallons of water; then the 2 pounds of resin and 1 pound of tallow is dissolved in 1 quart of the lye; after the resin is all well dissolved by moderate heat the lye is added slowly, while cooking, under continued stirring. The mixture, if good, will become dark brown and thick. Should it become whitish and flocky (this is caused by too much and too strong lye), water should be added and it will become right again. This will make 22 pints of soap—for water should be added to make that amount after all the lye is in—at a cost of 11 cents, excluding fuel and labor in preparing it, which amount to but little, and will be sufficient for 44 gallons of wash if sprayed well. This is for *Icerya*. I would not recommend it stronger than ⅓ cent for a gallon of the wash.

The same rule is to be observed in preparing soap No. 144. This has been tried also on two large trees by Messrs. Wolfskill and Craw, at ¼ cent per gallon of the wash. All eggs and insects were destroyed and the tree left in excellent condition.

In preparing these soaps the resin and tallow should never be dissolved without the additional lye. It will become so hot, that if a little lye is added a good part of the contents of the kettle will boil over. All this is avoided by adding the lye as said above, and the resin will dissolve the quicker.

In making tallow soap for experiment 77 the caustic soda should be dissolved in somewhat less water. One gallon is used. After the tallow and resin are dissolved together (in this soap it can be done without the lye) the lye should be added slowly while boiling, and afterward the required water added. Thirty-seven pints of soap were made in experiment 77 at ½ cent per pint. In using caustic soda the cost of same quantity—*i. e.*, 1 pound of soda, 5 cents; tallow, 2½ pounds, 7.5 cents; resin, ½ pound, 0.73 cent—would be only 13¼ cents; and in making 40 pints of soap this would be ⅓ cent per pint. One pint of soap to 7 pints of water would be sufficiently strong to kill the scales and their eggs.

A soap emulsion prepared cold is used extensively in and around Los Angeles. I have not seen any good results from it. If mixed with water free oil would float on the top, and trees treated with it would lose half their leaves and be arrested in growth for weeks. The fruit would be burned and marked from the excessive caustic it contains. I have seen several hundred trees in such condition in the Wolfskill orchard. The consistency of this particular mixture I could not learn. Never, and I have been assured so by experienced soap-men, can a proper soap be made except by cooking. Although my experiments 35 and 71 show good results, I would not recommend them.

RESIN COMPOUNDS.

These I found excellent for destroying *Icerya*, and the few experiments made on the Red Scale (*Aspidiotus aurantii*) showed promising results; yet further experi-

ments are required to be positive. The resin compound will penetrate the cottony mass of *Icerya* as well as, or even better than, soap. Yet its actions are slower, and if not used sufficiently strong, even if all the eggs are destroyed, some of the mother scales will not be killed by it, or if so, only after they have left a few fresh eggs, which will in due time hatch. Such eggs, if few, are brought forth loose, *i. e.*, without the usual protection of cottony exudation, and either drop to the ground or lie free above the destroyed egg-mass and under the dead mother. No doubt, many of these eggs never hatch, especially in hot weather.

It is quite different with eggs which are deposited by females that really survive treatment; the usual cottony mass is exuded, and thus the eggs are protected as usual and hatch always.

Its action on Red Scale is very promising, either mixed with soap or in simple emulsion, as experiments will show. Experiment 132, ½ pint of compound to 1 gallon of water, although costing only ⅛ cent per gallon of the wash, destroyed a large number of the scales; and a few days after application the covering became loose from the insect, so much so that some of them could be blown off and leave the insects exposed, affording an excellent opportunity for the mites, with which the tree was swarming, and which do not seem to be harmed by the wash.

A strong application of this emulsion will form a coating over everything on the tree, will exclude the insects from air for a few days, and will have entirely disappeared in a week in warm weather, as shown in experiment 134.

LYE SOLUTION.

A few experiments were made on hedges of young orange plants. Experiments 108–118 will show the results. While in every case the plant was more or less injured, the insects alone were killed, or part of them, and the contents of egg-sacs were not in the least affected, even with so strong an application that the plant was destroyed entirely.

BISULPHIDE OF CARBON.

A few experiments were made in fumigating with this article, but its action is too slow to be of value on large trees. Messrs. Wolfskill and Craw have made several experiments, and on trees of about 8 feet in diameter all the scales were destroyed in twenty-four hours. The trees were greatly benefited by it, as I am informed by these gentlemen.

KEROSENE EMULSION.

The cost of this article is too high for general use as a remedy for the Cottony Cushion-scale. An emulsion of "kerosene 1 gallon, soft soap ½ gallon, and water 1 gallon" (see experiment 41), cost about 24 cents for 2½ gallons of the emulsion. This is wholesale price. Three pints of this emulsion is required to 1 gallon of water to destroy both the *Icerya* and its eggs. This would be about 18 cents for 7 gallons of the wash.

In all the experiments made with this emulsion I have not seen the slightest injury done to the trees, as is the case with some of the soaps if used too strong.

Made in this way with soap, it penetrates the cottony mass more easily than if emulsified with some other substance.

Very good results were had with emulsion of petroleum. As this could be bought at from 6 to 7 cents per gallon in large quantities and combined with soap, it makes a reasonably cheap wash. The orange trees are left in an unsightly condition even for a month or six weeks after application, and it could therefore not be used on maturing fruit; yet if properly tried it may do good work on other scales on deciduous trees in the dormant state.

EXPERIMENTS.*

I now give in some detail an account of the more instructive of the experiments made, noting results in each case.

Experiment 18. Sheep-dip.

Sheep-dip, 1 pint; water, 15 pints. Applied July 9. On examination, July 16, found but few of the smaller scales killed; contents of egg-sacs not affected. Mr. Coquillett reported on other experiments with same mixture.

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*It will be noticed that the numbers of the experiments are not perfectly consecutive; but the omitted numbers will be found under the head of the "Red Scale", in the last section of the report.

Experiment 19. Emulsion of crude petroleum.

One gallon of crude petroleum; ½ gallon of soap of experiment 13 (consisting of whale-oil, 4 pints; potash, 1 pound; concentrated lye, 1 pound; and water, 7½ gallons), and ½ gallon of water. Applied May 4, and reported on by Mr. Coquillett. Soap and water were heated together first and petroleum added. This made a good emulsion after working for half an hour with hand pump, and remained stable for the next three weeks.

Emulsion, 1 pint; water, 1 gallon. Applied July 16. Will settle in drops on tree and not penetrate egg-masses. August 9, only a few of the smaller insects dead. Leaves spotted, but not injured.

Experiment 20. Emulsion of crude petroleum.

Emulsion, 2 pints; water, 1 gallon. Applied July 17. Will not penetrate egg-sac. August 9, found nearly all insects dead on trunk and large branches; young hatching numerously. The trunk and large limbs of tree remained free from scales for a long time after.

Experiment 21. Emulsion of crude petroleum and soap 13.

Emulsion, 1 pint; soap, 1 pint; water, 1 gallon. Applied July 17, and penetrated nearly all egg-masses. August 9, all insects killed and dry; a few of the eggs have hatched.

Experiment 22. Whale-oil soap and lime water.

Made of fish-oil, 3 pints; potash, 1 pound; water (in which 1 pound of slaked lime had stood for twenty-four hours*), 4 gallons.

Soap, ½ pint; water, 1 gallon. Applied July 31. Only a small part of scales killed and a few of the smaller egg-masses destroyed. Killed about half of the young Black Scale (*Lecanium oleæ*).

Experiment 23. Soap 22.

Soap, 1 pint; water, 1 gallon. Applied July 31. Will not penetrate all the larger egg-masses. August 8, a few of the mother scales still living; some young hatching. September 14, insects were not numerous.

Experiment 24. Soap 22.

Soap, 1½ pints; water, 1 gallon. Applied July 31 on lemon tree, with trunk and branches completely covered with scales. Penetrated all egg-masses. One hour after spraying, many dead Coleoptera, Hemiptera, and lace-wing flies were found on ground. August 8, occasionally a single living insect was found. August 23, insects few; very few young hatched; tree healthy and blooming.

Experiment 25. Whale-oil soap.

Made of fish oil, 9 pints; crude potash, 3 pounds; caustic soda, 1 pound; lime, 3 pounds; and water, 9½ gallons.

Soap, ½ pint; water, 1 gallon. Applied July 31. Will penetrate only smaller egg-masses. August 9, only a small part of scales killed. August 14, scales numerous; egg-masses covered with fungus.

Experiment 26. Soap 25.

Soap, 1 pint; water, 1 gallon. Applied July 31. Will penetrate all egg-masses. August 9, nearly all scales killed; a few newly hatched young on tree. September 14, scales few; tree in good condition.

Experiment 27. Soap 25.

Soap, 1½ pints; water, 1 gallon. Applied August 2. August 10, a few eggs found uninjured. August 14, some of the mother scales have produced fresh eggs before dying; others still living. September 14, scales quite numerous; tree healthy.

Experiment 28. Soap 25.

Soap, 2 pints; water, 1 gallon. Applied August 5 on lemon trees. Nearly all the scales were dry the following day. August 14, no living scales could be found; tree not injured.

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* Whenever lime was used, only the clear water was taken after the lime had settled to the bottom.

Experiment 29. Soap 22.

Soap, 2 pints; water, 1 gallon. Applied August 6. August 10, found all scales and egg-masses hard; tree not injured. September 15, many scales have come on tree again; it is healthy and blooming.

Experiment 30. Soap 25 and crude carbolic acid.

Soap, 6 pints; crude carbolic acid, emulsified, $\frac{1}{8}$ pound; water, 6 gallons. Applied August 7. Did not penetrate egg-masses well. August 23, living scales quite numerous.

Experiment 31. Soap 25 and petroleum emulsion.

Soap, 2 pints; emulsion, 1 pint; water, 3 gallons. Applied August 8. August 10, scales nearly all dead but not dry, having an inflated appearance. August 14, a few scales have recovered. September 14, tree clean; scales very few.

Experiment 32. Soap 25. Petroleum emulsion.

Soap, 2 pints; emulsion, 1 pint; water, 2 gallons. Applied August 9. Destroyed all scales and eggs. September 14, occasionally one scale on branches only; none on stem. Tree healthy; fruit not injured or spotted.

Experiment 34. Soap 25. Petroleum emulsion.

Soap, 3 pints; emulsion, 1 pint; water, 2 gallons. Applied August 9. Found scales and egg-masses hardened the following day and many dead insects on ground. September 14, very few scales; stem and large branches entirely free; tree healthy and growing.

Experiment 35. Soap made cold. Soap emulsion.

One pound of potash was dissolved in 1 quart of water; 2 pints of fish-oil made lukewarm, and the lye slowly added under continued stirring; then $\frac{1}{2}$ gallon of water, in which 1 pound of slaked lime had been, was added. After two days water was added to make 36 pints, and in a week it had become an emulsion or imperfect soap. One pint of this (costing 1 cent) to 1 gallon of water. Applied August 11. Will penetrate all egg-masses well. August 14, found all scales and eggs destroyed. August 17, black sticky drops remained on fruit and leaves had begun to drop. September 14, occasionally one young scale; black drops had disappeared from fruit, not leaving any mark. About one-quarter of the leaves have fallen.

Experiment 36. Emulsion 35.

Heated emulsion to cooking-point; then took 1 pint to 1 gallon of water. This did not penetrate egg-masses well, and many of the larger remained dry inside. Destroyed all of the scales, but some of the eggs hatched and young became numerous. Many leaves dropped.

Experiment 37. Whale-oil soap.

Made of potash, 1 pound; fish-oil, 2 pints; and water to make 36 pints of soap, costing $\frac{1}{2}$ cent per pint.

Soap, 2 pints; water, 1 gallon. Applied August 13. This penetrated all egg-masses well, and all the scales were found dead the next day. August 17, scales and egg-masses hard.

Experiment 38. Soap 37.

Soap, 1 pint; water, 1 gallon. Applied August 13. Will not penetrate egg-masses well. About half of the eggs and scales killed.

Experiment 39. Soap 37. Petroleum emulsion

Soap, 5 pints; emulsion, 1 pint; water, 42 pints. Applied August 13. Tree well sprayed. All the scales were found dead the next day. Only a few of the eggs hatched, but scales were numerous again September 14.

Experiment 40. Soap 37. Petroleum emulsion.

Soap, 5 pints; emulsion, 1 pint; water, 4 gallons. Applied August 16. On the 18th all the scales killed; egg-masses hard. August 23, a few scales on stem again. September 14, scales increasing, especially on stem; tree and fruit not injured or discolored.

Experiment 41. Kerosene emulsion.

Kerosene, 1 gallon; soap, 37½ gallons; water, 1 gallon. Soap and water heated and all worked together for half an hour with pump. This formed a cream-white emulsion and became as thick as cream on cooling.

One pint of this emulsion to 1 gallon of water. Applied August 16. Did not penetrate egg-masses; killed only a small part of young scales. September 14, tree full of scales.

Experiment 42. Kerosene emulsion 41.

Emulsion, 2 pints; water, 1 gallon. Applied August 16. Did not penetrate egg-masses well. Found next day about half of the eggs destroyed, also about half of the scales were dead; several dead Coleoptera on ground. August 23, a few of the scales still living; eggs hatching. September 14, a few of the mother scales still living; young hatching numerously.

Experiment 43. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 1 pint; water, 1 gallon. Applied August 16. Tree well sprayed; penetrated nearly all the egg-masses. August 23, a few insects still living. September 14, scales numerous; Black Scale (*L. oleæ*) not all dead.

Experiment 44. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 3 pints; water, 4 gallons. Applied August 16. Tree sprayed well, and nearly all egg-masses were found wet. August 18, about half of the scales dry, the others still soft but inflated; some of the egg-masses dry in center. August 23, young hatching occasionally. September 14, scales numerous again

Experiment 45. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 3 pints; water, 2 gallons. Applied August 17. Had penetrated all egg-masses well after spraying; found 3 dead larvæ of *Tortrix* on stem, destroyed by wash. August 23, occasionally one living insect; no young hatching. September 14, few insects on branches, but stem full.

Experiment 46. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 5 pints; water, 6 gallons. Applied August 17 on lemon tree. Did not penetrate egg-masses well; killed one-half of the eggs and three-fourths of the scales. In a short time the tree was full again.

Experiment 47. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 5 pints; water, 4 gallons. Applied August 18. Occasionally one of the mother scales survived, but very few young hatched.

Experiment 51. Kerosene emulsion 41.

Emulsion, 3 pints; water, 1 gallon. Applied August 25. Tree full of *Icerya* and Red Scales. Penetrated all egg-masses well; killed eggs and insects of *Icerya*. Only a few young of Red Scale hatched; old all destroyed.

Experiment 63. Tar soap.

Made of fish-oil, 2 pints; pine tar, 1 pint; potash, 1 pound; water, 4 gallons.

Soap, 1 pint; water, 1 gallon. Applied August 31. September 10, some of the mother insects still living and producing fresh eggs. September 18, all insects covered with fungus; some of the mother scales living; young hatching.

Experiment 64. Tar soap 63.

Soap, 2 pints; water, 1 gallon. Applied August 31. Penetrated all egg-masses well, and all scales and eggs were destroyed; tree not injured.

Experiment 65. Tar soap 63.

Soap, ½ pint; water, 1 gallon. Applied August 31. Killed only a small part of young scales and small egg-masses.

Experiment 68. Tobacco soap.

Made of tobacco, ½ pound; fish-oil, 2 pints; potash, 1 pound; and water to make 42 pints of soap.*

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*The tobacco is placed in a bag and well cooked with part of the lye, and this is added after the soap is complete.

Soap, 1 pint; water, 1 gallon. Applied September 2. Penetrated only smaller egg-masses well. September 6, occasionally one scale living; no young as yet have hatched. September 11, scales still dying; large females, although living, yet soft and sickly; noticed many walking down on trunk of tree. No newly hatched young could be found. November 4, scales few; tree in good condition.

Experiment 69. Tobacco soap 68.

Soap, 1½ pint; water, 1 gallon. Applied September 2. Will not penetrate egg-masses well. November 6, no living insects found. November 11, occasionally one moving scale; nearly everything dry. September 14, a few of the mother scales are depositing fresh eggs, but without cottony mass, lying exposed. November 4, scales very few; tree healthy.

Experiment 70. Tobacco soap 68.

Soap, 2 pints; water, 1 gallon. Applied September 2. Will penetrate all egg-masses if sprayed well. Pump broke and tree was not sprayed well. September 6, all eggs destroyed and nearly all the insects; a few were observed leaving the tree. September 18, quite a number of living scales on tree; some still dying. November 4, scales few; tree healthy.

Experiment 71. Soap emulsion 35.

Another trial of this emulsion was made; contents same as in 35. The mixture was stirred every day and used on the tenth day.

One pint of this emulsion to 1 gallon of water. Applied September 2 on large tree; 10 gallons of the wash used. Penetrated all egg-masses. September 6, all eggs and scales destroyed. Result about the same as in 25, but not quite as many leaves fell. October 7, tree remarkably clean, growing well; fruit not marked.

Experiment 74. Whale-oil soap.

Made of whale-oil, 3 pints; potash, 1 pound; water to make 40 pints of soap; costing about ½ cent per pint. This was not as perfect as when only 2 pints of oil were used.

Soap, 1 pint; water, 1 gallon. Applied September 6. Result, about three-fourths of scales and eggs killed.

Experiment 75. Soap 74.

Soap, 1½ pints; water, 1 gallon. Applied September 6. Result: Will destroy eggs and scales, but also tips and budding leaves or tender shoots; the older leaves did not fall.

Experiment 76. Soap 74.

Soap, 2 pints; water, 1 gallon. Applied September 6. Killed scales and eggs; result on tree about the same as in 75.

Experiment 77. Tallow soap.

Made of tallow, 2½ pounds; resin, ½ pound; potash, 1 pound; and water to make 34 pints of soap; costing ½ cent per pint.

Soap, 1 pint; water, 1 gallon. Applied September 9. Wash will penetrate all egg-masses well. September 10, eggs and insects destroyed; nearly everything hard. Nothing escaped this wash, and the tree was not in the slightest injured or arrested in its growth.

Experiment 78. Soap 77.

Soap, 1½ pints; water, 1 gallon. Applied September 9. Killed scales and eggs; tree not injured.

Experiment 79. Soap 77.

Soap, ½ pint; water, 1 gallon. Applied warm, September 9. Penetrated only smaller egg-masses well. About half of the scales and eggs destroyed.

Experiment 84. Soap of fish-oil, tobacco, and resin.

Made of fish-oil, 2 pints; resin, ½ pound; tobacco, ½ pound; potash, 1 pound; and water, 3 gallons.

Soap, ½ pint; water, 1 gallon. Applied September 11. Many of the scales survived, and only small part of the eggs were destroyed.

Experiment 85. Soap 84.

Soap, 1 pint; water, 1 gallon. Applied September 11. September 18, some of the scales hardened and others became inflated. One of the mother scales deposited 6 more eggs before dying and one of the young hatched. On September 22 all had

hardened. October 5, no young scales; tree covered with fungus. November 4, fungus loose; scales very few; tree in good condition.

Experiment 86. Soap 84.

Soap, $1\frac{1}{2}$ pints; water, 1 gallon. Applied September 11. On the 18th some of the insects were still dying. On the 30th all were hard. October 5, tree full of fungus

Experiment 87. Soap 77.

Soap, $\frac{1}{2}$ pint; water, 1 gallon. Applied September 11. Tree well sprayed, and most of the egg-masses were penetrated by wash. Result: Nearly all the eggs destroyed; only a few mother scales survived and produced fresh eggs.

Experiment 88. Resin soap.

Made of resin, 2 pounds; tallow, 1 pound; potash, 1 pound; and water to make 20 pints of soap; costing $\frac{3}{4}$ cent per pint.

Soap, $\frac{1}{2}$ pint; water, 1 gallon. Applied September 13. Penetrated all egg-masses well. September 18, some of the scales began to dry up; no fresh eggs. September 22, all dead, but not hard. October 4, occasionally one young scale; tree in fine condition.

Experiment 89. Soap 88.

Soap, 1 pint; water, 1 gallon. Applied September 13. The scales were all dead on the 22d, but not hard. October 5, scales and eggs destroyed; tree in good condition.

Experiment 90. Soap 88.

Soap, $1\frac{1}{2}$ pints; water, 1 gallon. Applied September 13. Destroyed scales and eggs, although they were not hard on the 22d. October 5, no living scales; tree in good condition.

Experiment 92. Tobacco soap.

Made of tobacco, $\frac{1}{2}$ pound; tallow, $1\frac{1}{2}$ pounds; resin, $1\frac{1}{2}$ pounds; potash, 1 pound; and water to make 40 pints of soap; costing $\frac{1}{2}$ cent per pint.

Soap, $\frac{1}{2}$ pint; water, 1 gallon. Applied September 15. Tree well sprayed. Result: Nearly all the scales and eggs destroyed; scales die very slowly; some Hemiptera and Coccinellids found dead on ground.

Experiment 93. Soap 92.

Soap, $\frac{3}{4}$ pint; water, 1 gallon. Applied September 15. September 17, all eggs and scales seem to be destroyed. September 22, insects not yet all dry, but dead; tree in very good condition. Wash sufficiently effective.

Experiment 94. Soap 92.

Soap, 1 pint; water, 1 gallon. Applied September 15. Penetrated all egg-masses well and destroyed everything. September 22, scales not hardened; nothing living.

Experiment 99. Resin soap.

Made of resin, 3 pounds; tallow, 1 pound; potash, 1 pound; and water to make 32 pints of soap; costing $\frac{1}{2}$ cent per pint.

Soap, $\frac{1}{2}$ pint; water, 1 gallon. Applied September 20 on large and dirty tree full of fungus, almost covering some of the egg-masses. Nearly all the eggs were destroyed. Some of the mother scales recovered and produced fresh eggs.

Experiment 100. Soap 99.

Soap, $\frac{3}{4}$ pint; water, 1 gallon. Applied September 20. Had penetrated all egg-masses after spraying. September 22, nearly all scales killed. October 12, occasionally one living scale.

Experiment 101. Soap 99.

Soap, 1 pint; water, 1 gallon. Applied September 22. Some of the mother scales were still living on the 24th, yet all had died on September 30, but were not dry. November 2, tree nearly clean of scales. It was also thickly infested with Red Scale, but all these were killed.

Experiment 102. Soap 77 and lime water.

One pound of slaked lime in 20 pints of water. After the water became clear $\frac{1}{2}$ pint of this was taken with $\frac{1}{2}$ pint of soap to $7\frac{1}{2}$ pints of pure water. Applied September 24. Result: All eggs destroyed and scales all dead after six days, although a few fresh eggs were left. Tree not injured. The trees were very thoroughly sprayed. The result would not have been so good with a light spraying.

Experiment 103. Tobacco soap 92; lime water 102.

Soap, ½ pint; lime water, ½ pint; water, 7½ pints. Applied September 24. Result not as good as in 102, as a number of mother scales survived. October 5, found a number of living scales, fresh eggs, and newly hatched young.

Experiment 104. Resin soap 99; lime water 102.

Soap, ½ pint; lime water, ½ pint; water, 7½ pints. Applied September 24. Result as in 102; very few living scales October 4.

Experiment 108. Babbitt's potash lye.

Potash, 1 pound; water, 2 gallons. Applied September 29. Result; Killed all insects, but did not injure contents of egg-sacs; nearly all leaves dropped; tender shoots killed and bark burned.

Experiment 109. Babbitt's potash lye.

Potash, 1 pound; water, 4 gallons. Applied September 29. Result: Killed scales; did not injure contents of egg-sacs; tips of plant destroyed; leaves badly burned in spots.

Experiment 110. Babbitt's potash lye.

Potash, 1 pound; water, 6 gallons. Applied September 29. Killed all free young and nearly all of the mother scales, contents of egg-sacs uninjured; tips of plant broken off; leaves spotted in parts.

Experiment 111. Babbitt's potash lye.

Potash, 1 pound; water, 8 gallons. Applied September 29. Only part of scales killed; contents of egg-sacs uninjured; tips of plant injured; leaves spotted in parts.

Experiment 112. Babbitt's concentrated lye.

Concentrated lye, 1 pound; water, 2 gallons. Applied September 29. Scales al killed; contents of egg-sacs uninjured; all leaves dropped; tips of plant killed; bark burned in parts.

Experiment 113. Babbitt's concentrated lye.

Concentrated lye, 1 pound; water, 4 gallons. Applied September 29. Killed all scales, not injuring contents of egg-sacs; tips of plant killed; one-third of the leaves dropped, remainder all spotted.

Experiment 114. Gillett's concentrated lye.

Concentrated lye, 1 pound; water, 1 gallon. Applied September 29. Scales all killed; contents of egg-sacs uninjured; plant entirely killed.

Experiment 115. Gillett's concentrated lye.

Concentrated lye, 1 pound; water, 2 gallons. Applied September 29. Killed all scales; contents of egg-sacs uninjured. Some of the shoots killed near ground; only a few leaves remaining near the ground.

Experiment 116. Gillett's concentrated lye.

Concentrated lye, 1 pound; water, 4 gallons. Applied September 29. Killed scales, not injuring contents of egg-sacs; tips of plant destroyed; leaves spotted.

Experiment 117. Gillett's concentrated lye.

Concentrated lye, 1 pound; water, 6 gallons. Applied September 29. About half of the mother scales survived; contents of egg-sacs not injured; tips of plants destroyed.

Experiment 118. Gillett's concentrated lye.

Concentrated lye, 1 pound; water, 12 gallons. Applied September 29. Only a few of the scales killed; contents of egg-sacs not injured; tips of plants destroyed

Experiment 119. Lime water.

One pound of slacked lime in 20 pints of water. Applied September 29. Killed only a few of the scales; all became completely covered by fungus. This had disappeared again November 4, and insects were in good condition.

Experiment 120. Resin soap.

Made of resin, 3 pounds; tallow, 1 pound; caustic soda, 1 pound; and water to make 25 pints of soap; costing ½ cent per pint.

Soap, ½ pint; water, 1 gallon. Applied October 4 on large tree. Three gallons of wash were required; only lightly sprayed. Scales died slowly; mother scales left a few fresh eggs. October 14, occasionally one young scale found.

[*All experiments after* 120 *only lightly sprayed.*]

Experiment 121. Soap 120.

Soap, 1 pint; water, 3 gallons. Applied October 4. Will penetrate egg-masses in about 3 minutes. A few of the scales recovered and produced fresh eggs.

Experiment 122. Resin compound.

Made of resin, 4 pounds; soda ash (pure carbonate of soda), 1 pound; water to make 36 pints of compound; costing 11 cents.

Compound, 1 pint; water, 3 gallons. Applied October 4. Only penetrated smaller egg-masses. Killed only a few of the smaller scales, and a few eggs only were destroyed.

Experiment 123. Resin compound 122.

Compound, 1 pint; water, 2 gallons. Applied October 4; did not penetrate egg-masses well, and only about half of them were destroyed. Many mother scales survived.

Experiment 124. Resin compound 122.

Compound, 1 pint; water, 1½ gallons. Applied October 4. Penetrated all but the largest egg-masses well. Some of the mother scales and some eggs escaped.

Experiment 125. Resin compound 122.

Compound, 1 pint; water, 1 gallon. Applied October 4. Penetrated all egg-masses well. A few of the mother scales survived and produced fresh eggs. None of the eggs sprayed have hatched.

Experiment 126. Resin soap 120.

Soap, 1 pint; water, 4 gallons. Applied October 4. Penetrated only smaller egg-masses. Killed most of the smaller scales, but only a few of the smaller egg-masses were destroyed.

Experiment 129. Resin compound.

Made of resin, 4 pounds; common washing soda (carbonate of soda), 3 pounds; water to make 36 pints of compound; costing ¼ cent per pint.

Compound, 1 pint; water, 2 gallons. Applied October 7. Will penetrate only smaller egg-masses. A few young scales only and small portion of eggs destroyed.

Experiment 130. Resin compound 129.

Compound, 1 pint; water, 1½ gallons. Applied October 7. Did not penetrate larger egg-masses. Destroyed all smaller ones and a few of the mother scales. November 4, scales numerous on tree.

Experiment 131. Resin compound 129.

Compound, 1 pint; water, 1 gallon. Applied October 7. Penetrated all egg-masses well on slight spraying. October 11, a few mother scales, which were protected by fungus, still living. October 14, all scales dead; occasionally a few eggs left among fungus.

Experiment 134. Resin compound 129.

Half compound and half water, to see effect on plants. Applied October 7. Will penetrate egg-masses instantly on application. All scales and egg-masses hard on examination two days after; plant as if varnished and sticky. This had disappeared on October 13, leaving the plant in excellent condition, not a leaf having dropped.

Experiment 135. Resin compound.

Made of resin, 4 pounds; caustic soda, 1 pound; and water to make 33 pints of compound; costing ¼ cent per pint.

Compound, 1 pint; water, 2 gallons. Applied October 8. Will penetrate only smaller egg-masses on light spraying; many of the mother scales survived and young were numerous November 4.

Experiment 136. Resin compound 135.

Compound, 1 pint; water, 1½ gallons. Applied October 8. Did not penetrate larger egg-masses well on light spraying; many of the mother scales survived, and October 25 occasionally a single young could be found.

Experiment 137. Resin compound 135.

Compound, 1 pint; water, 1 gallon. Applied October 8. Will penetrate all egg-masses well on light spraying in about two minutes. October 11, some of the mother scales still living, but no fresh eggs could be observed. October 14, scales all dead. November 4, no young have hatched; tree not injured.

Experiment 138. Resin soap.

Made of resin, 2 pounds; tallow, 2 pounds; caustic soda, 1 pound; and water to make 28 pints of soap; costing ½ cent per pint.

Soap, 1 pint; water, 2 gallons. Applied October 14. Did not penetrate egg-masses; killed most of smaller scales, but had no effect on contents of egg-sacs.

Experiment 139. Soap 138.

Soap, 1 pint; water, 1½ gallon. Applied October 14. Will penetrate only the smaller egg-masses well. October 16, all scales are dead. November 4, no young had hatched.

Experiment 140. Soap 138.

Soap, 1 pint; water, 7 pints. Applied October 14. Will penetrate all egg-masses well on light spraying. October 16, no living scales could be found.

Experiment 141. Resin compound.

Made of resin, 4 pounds; washing soda, 3 pounds; and water to make 24 pints of compound. This is somewhat thick, and will not so readily mix with water as 129, especially after cooling.

Compound, 1 pint; water, 1½ gallon. Applied October 15. Penetrated all egg-masses and destroyed them; some of the mother scales produced fresh eggs before dying. Found no living scales October 25.

Experiment 142. Resin compound 141.

Compound, 1 pint; water, 1 gallon. Applied October 15. Will penetrate all egg-masses well in about 2 minutes with light spraying. Found no living scales October 16.

Experiment 143. Resin compound 141.

Compound, 2 pints; water, 1½ gallons. Applied October 15. Will penetrate immediately. October 16, nothing living. October 28, scales still soft, but rotten. November 4, no living scales on tree, which was left in fine condition, with the wash still visible.

Experiment 144. Resin soap.

Made of resin, 1½ pounds; tallow, 1½ pounds; caustic soda, 1 pound; and water to make 23½ pints of soap; costing ½ cent per pint.

Soap, 1 pint; water, 2 gallons. Applied October 18. Penetrated all but a few large egg-masses well with light spraying. October 23, all scales dead; no fresh eggs. October 28, found occasionally one newly hatched larva.

Experiment 145. Soap 144.

Soap, 1 pint; water, 1½ gallons. Applied October 18. Destroyed all eggs and insects.

Experiment 146. Soap 144.

Soap, 1 pint; water, 1 gallon. Applied October 18. All egg-masses well penetrated after spraying; destroyed all eggs and scales; not the slightest injury done to the tree.

Experiment 152. Resin soap.

Made of resin, 2 pounds; tallow, 1 pound; caustic soda, 1 pound; and water to make 25 pints of soap; costing 11 cents.

Soap, 1 pint; water, 2 gallons. Applied October 27. Will penetrate nearly all egg-masses with light spraying. November 1, all scales dead; no fresh eggs left; a few of the old eggs will hatch.

Experiment 153. Soap 152.

Soap, 1 pint; water, 1½ gallons. Applied October 27. Will penetrate all egg-masses well in about two minutes after a light spraying. Next day some of the mother scales were still living, but all were dead October 30, and no fresh eggs were left. November 4, nothing living; fungus loosening and coming off; tree in fine condition.

Experiment 157. Resin compound.

Made of resin, 30 pounds; caustic soda, 3 pounds; and water to make 230 gallons of wash; at a cost of 60 cents. Sprayed by Mr. Alexander Craw, and reported in letter of November 22. White Scale when well saturated die, but when only lightly sprayed form new wax. Black Scale all dead. As a wash for Black Scale in the fall and winter it will be admirable, but for the most thorough work only 180 gallons of water should be taken.

Experiments on Fumigation with Bisulphide of Carbon.

Experiment 1.—September 29. One and a half fluid ounces in 1-pound tin can were set on the ground near young shoots of orange, and a 50-gallon cask placed over this for three hours. After removing cask only half of the carbon had evaporated; scales seemed to be dead. On examining next day found all of them living.

Experiment 2.—September 29. Poured three-fourths fluid ounce into bottom of cask; placed this over young plants at 3 p. m.; left until 1 p. m. next day. All the insects were found dead, and had changed their color to a light hyacinth red. October 4, leaves began to drop. October 7, nearly all eggs had changed to straw color. About three-fourths of the leaves dropped, and the plant had not recovered November 1.

Experiment 3.—September 30. One and a half fluid ounces in 1-pound tin can set under cask and left for 20 hours. Destroyed all scales and eggs. About one-third of the leaves dropped.

Experiment 4.—October 1. One and a half fluid ounces poured into cask and placed over plants for 3 hours. Killed all scales and eggs. No leaves dropped, and the plant has not in the least been injured.

Experiment 5.—October 14. Made on tree about 7 feet high and 5 inches in diameter, under tent. Two fluid ounces in shallow tin pan placed in middle of tree from 11 a. m. until 3 p. m. Destroyed all the scales except those on a few of the lowest branches, where the eggs also remained uninjuied. Tree not injured; no leaves dropped.

Experiment 6.—October 22. On tree about 8 feet in diameter, under tent. Six fluid ounces in shallow tin pan set in middle of tree at 3.30 p. m. and left until 6.30 p. m. Had no effect whatever on scales.

EXPERIMENTS ON RED SCALE (*Aspidiotus aurantii*).

Experiment 33. Soap 25.

Soap, 2 pints; water, 1 gallon. Applied August 5. August 14, nearly all scales killed; a few mother scales with eggs and young living. October 5, only a few newly formed scales could be found.

Experiment 48. Kerosene emulsion and soap 37.

Kerosene emulsion, 1 pint; soap, 5 pints; water, 4 gallons. Applied August 18. Tree full of scales; some of the branches already destroyed. August 23, many young scales have hatched; only part of large scales dead. September 24, about one-fifth of old scales living; many young on tree.

Experiment 49. Soap 37.

Soap, 3 pints; water, 1 gallon. Applied August 18. Tree thickly infested with *Icerya* and Red Scales. August 23, scales nearly all dead and dry; a few young. September 24, a few of the old scales still living; occasionally a young larva found; tree in good condition.

Experiment 50. Soap 37.

Soap, 3 pints; water, 1 gallon. Applied August 18. Tree thickly infested with scales; half of the branches killed. August 23, about half the leaves have dropped. September 6, leaves have ceased dropping; tree recovering; occasionally one young scale found. September 18, tree pushing out new shoots. November 4, tree growing vigorously; young scales very few.

Experiment 52. Kerosene emulsion 41.

Emulsion, 4 pints; water, 1 gallon. Applied August 25 on tree infested with *Icerya* and Red Scale. August 28, *Icerya* all destroyed, Red Scales apparently so. September 24, a few gravid females still living; occasionally a single newly formed scale.

Experiment 53. Kerosene emulsion 41; soap 37.

Emulsion, 2 pints; soap, 1 pint; water, 1 gallon. Applied August 25. August 28, many young scales forming. September 7, about 10 per cent. of old scales living; many young forming. November 4, tree swarming with scales.

Experiment 54. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 2 pints; water, 1 gallon; Applied August 25. September 7, found two mother scales living; young forming quite numerously. October 5, tree full of young scales.

Experiment 55. Kerosene emulsion 41; soap 37.

Emulsion, 3 pints; soap, 1 pint; water, 1 gallon. Applied August 25 on small and faded tree. September 7, leaves nearly all off; many young scales forming. September 22, branches all dead; many young scales on stem; no living adults.

Experiment 56. Kerosene emulsion 41; soap 37.

Emulsion, 1 pint; soap, 3 pints; water, 1 gallon. Applied August 25. August 28, found a few living young under mother scale. September 7, many newly formed scales. September 24, old scales all dead; young quite numerous. October 5, scales very few; tree doing well.

Experiment 57. Kerosene emulsion 41.

Emulsion, 5 pints; water, 1 gallon. Applied August 31 on small and sickly tree. September 7, no living old scales; only two living young could be found. September 24, leaves all off; scales few. October 5, tree pushing out new shoots on stem; some branches still living. November 4, tree growing; scales few

Experiment 58. Kerosene emulsion 41.

Emulsion, 6 pints; water, 1 gallon. Applied August 31. Tree lightly sprayed. September 22, a few of the mother scales still living; young forming quite numerously. October 5, no living old scales; young few; tree in good condition.

Experiment 59. Kerosene emulsion 41.

Half emulsion and half water. Applied August 31. Tree sickly and thickly infested with *Icerya* and Red Scale; also many Black Scales; many branches already dead. On very careful examination September 7 found one gravid female still living and some young scales forming. September 24, tree bringing forth new shoots on stem; young scales quite numerous. October 5, upper part of tree all dead, although growing well below; scales few.

Experiment 60. Soap 37.

Soap, 4 pints: water, 1 gallon. Applied August 31 on small and faded tree thickly infested with *Icerya* and Red Scale. September 7, found two moving young; leaves remaining only on lower branches. September 24, tree nearly dead; trunk again covered with *Icerya*. October 5, tree shooting out below; scales few.

Experiment 61. Soap 37.

Soap, 6 pints; water, 1 gallon. Applied August 31 on small and withered tree full of *Icerya*, Red and Black Scales. September 7, all scales destroyed; occasionally one young forming. September 24, a few young scales; tree shooting out again. October 5, hardly any Red Scales, yet the tree is covered again with Cottony Cushion-scale.

Experiment 62. Soap 37.

Half soap and half water. Applied August 31. September 7, scales all destroyed; on careful examination only one moving young could be found; only a few leaves had dropped. October 5, tree shooting out everywhere. November 4, tree almost free from scales and growing vigorously.

Experiment 66. Tar soap 63.

Soap, 2 pints; water, 1 gallon. Applied September 2 on tree that had been nearly killed by the scales. September 6, scales not all killed; young hatching numerously. October 5, some of the older scales still living; young numerous; tree nearly dead.

Experiment 67. Tar soap 63.

Soap, 4 pints; water, 1 gallon. Applied September 2 on large tree covered with scales. September 22, found only a very few young; old scales all dead; tree not

injured by wash. November 4, on careful examination only a few young scales could be found.

Experiment 72. Tobacco soap 68.

Soap, 2 pints; water, 1 gallon. Applied September 3 on thickly infested and nearly dead tree. September 22, only about three-fourths of the scales killed. October 5, living scales of all sizes present, but not abundant.

Experiment 73. Tobacco soap 68.

Soap, 4 pints; water, 1 gallon. Applied September 3 on small and sickly tree; some of the branches already killed by scales. September 7, scales not yet all dead; tips of young shoots somewhat injured, and a few of the old leaves dropping. September 22, no living scales; tree recovering. October 5, not a single scale could be found on most careful examination; tree in fine condition, growing vigorously.

Experiment 82. Soap 77.

Soap, ½ pint; water, 1 gallon. Applied September 9. September 18, only a small part of the scales killed. October 5, about four-fifths of the scales dead.

Experiment 83. Soap 77.

Soap, 1½ pints; water, 1 gallon. Applied September 9. September 18, all scales killed; not the slightest injury done to tree by wash. October 5, not a living scale could be found; tree in fine condition.

Experiment 95. Tobacco soap 92.

Soap, 1 pint; water, 1 gallon. Applied September 18. October 5, scales nearly all killed; young hatching quite abundantly. October 28, no living adults; young numerous.

Experiment 96. Tobacco soap 92.

Soap, 2 pints; water, 1 gallon. Applied September 18. October 5, a few gravid females living; a few young hatching. October 28, only young scales could be found, but these were quite numerous; tree in good condition.

Experiment 97. Tobacco soap 92.

Soap, 3 pints; water, 1 gallon. Applied September 18. September 24, tree not injured. October 11, all scales dry; no young could be found.

Experiment 98. Resin soap 88.

Soap, 1 pint; water, 1 gallon. Applied September 18. September 24, scales dying slowly; blossoms and budding leaves not injured. October 5, occasionally one gravid female living; very few young.

Experiment 105. Resin soap 99.

Soap, 1 pint; water, 1 gallon. Applied September 27. October 5, scales apparently all killed; found two newly-formed young. October 11, old scales all dead; young quite numerous.

Experiment 106. Resin soap 99.

Soap, 2 pints; water, 1 gallon. Applied September 27. October 5, scales apparently all dead; have changed in color; a few leaves dropping. October 11, scales all killed; not a single young scale could be found; tree not injured.

Experiment 107. Resin soap 99.

Soap, 4 pints; water, 1 gallon. Applied September 27. October 5, all scales discolored; not yet dry; leaves dropping. October 7, leaves still dropping. October 11, leaves have ceased dropping; all scales dead; no young. October 28, not a living scale could be found; tree in good condition.

Experiment 127. Resin soap 120.

Soap, 1 pint; water, 1 gallon. Applied October 4. October 11, all young and nearly all old scales dry; found two moving young. October 16, scales all dead. November 4, occasionally one young scale.

Experiment 128. Resin soap 120.

Soap, 2 pints; water, 1 gallon. Applied October 4. October 11, all scales dead and dry; tree not in the least injured. On the most careful examination, October

16 and 22, and November 1 and 4, I was unable to find any living scales; tree was growing nicely at last-mentioned date.

Experiment 132. Resin compound 129.

Compound, ½ pint; water, 1 gallon. Applied October 7. October 12, all young scales dry; old scales all loose and changed in color. October 15, old scales seem to be dead, yet not dry; found many dead young under mother scales. November 4, about three-fourths of the scales killed; they became firm again on the leaves after two weeks; mites very numerous.

Experiment 133. Resin compound 129.

Compound, 1 pint; water, 1 gallon. Applied October 7. October 12, nearly all scales dead and dry and changed in color; all the scales on insects that were not dry loose and easily removed; mites very numerous. October 15, no living scales could be found. October 22, found three newly formed scales. November 4, very few young and no living old scales could be found; tree not in the least injured; no leaves dropped.

Experiment 147. Resin soap 144.

Soap, 1 pint; water, 2 gallons. Applied October 23. October 28, found several moving young and a few newly formed scales. November 4, a few gravid females still living; young increasing.

Experiment 148. Resin soap 144.

Soap, 1 pint; water, 1 gallon. Applied October 23. October 28, all scales killed; found one moving young. November 4, occasionally one young; no old scales could be found.

Experiment 149. Resin soap 144.

Soap, 2 pints; water, 1 gallon. Applied October 23. October 28, budding leaves destroyed; old leaves dropping. November 1, a few leaves still dropping; tree had been in poor condition, and this experiment was made chiefly to see result of wash.

Experiment 154. Resin soap 152.

Soap, 1 pint; water, 1½ gallons. Applied October 27. November 3, nearly all scales killed; some of the mother scales not yet dry.

Experiment 155. Resin soap 152.

Soap, 1 pint; water, 1 gallon. Applied October 27. November 3, found all scales dead; no young could be found.

Experiment 156. Resin compound 141.

Compound, 2 pints; water, 1 gallon. Applied November 2. November 4, all scales have changed on tree as well as on fruit. Mr. Craw examined the tree again for me September 22, and he writes that all the young scales were dead, but many of the old scales were living.

Experiments 154 and 155 were made at a late date, and the results perhaps would vary a little if examined a month later; yet the soap will do excellent work on *Icerya* at ¼ cent per gallon with strong spray. I believe that the wash of experiment 154 would not kill all the Red Scales. The soap of experiment 120 is but little different, yet this destroyed all the Red Scales, at ⅓ cent per gallon of the wash, as sprayed by Messrs. Wolfskill and Craw.

In regard to experiment 156, Mr. Craw's statement is contrary to my expectations. Although I had at the time of spraying a poor pump, and the tree had not been sprayed well, yet the spray would miss the young as well as the old scales.

I examined tree of Experiment 133 often and carefully. In eight days nearly all the scales were dry. This is the same wash as that of 156, but costs only ⅓ cent for 9 pints of the wash, while in experiment 156 the cost would be 1 cent for 10 pints of the wash.

Resin compound is a good remedy in destroying *Icerya* and its eggs, and further experiments will show the value of it on Red Scale.

The best results so far on the Red Scale were had with soaps 120, 144, and 152, and these last two are also best for *Icerya*.

The fact that there are nearly always, even with the strongest washes, young scales found afterward may be largely due to the fact that the ground below thickly infested trees is always covered with infested leaves which have dropped, and naturally most of the young will crawl back upon the tree again after the spraying. They will also come from surrounding plants.

INSECTS AFFECTING SMALL GRAINS AND GRASSES.

By F. M. WEBSTER, *Special Agent.*

LETTER OF TRANSMITTAL.

LA FAYETTE, IND., *November* 2, 1886.

SIR: I herewith transmit my annual report for the current year, containing a continuation of my studies of the Wheat Isosoma, and a new pest, the Companion Wheat-fly; notes on *Meromyza americana*, and some insects affecting Barley; a list of insects frequenting or depredating upon Buckwheat; notes upon the destruction of timothy meadows by the Glassy Cut-worm; and two enemies of the White Clover.

As usual, I am under obligation to yourself and assistants for the determination of material, and numberless other favors.

Respectfully submitted.

F. M. WEBSTER,
Special Agent.

Dr. C. V. RILEY,
Entomologist.

INSECTS AFFECTING FALL WHEAT.

THE WHEAT-STRAW ISOSOMA.

(*Isosoma tritici* Riley.)

Up to June of the present year matters remained very much as they were left in my previous report, so far as obtaining any additional facts relative to the habits of this species is concerned. Straws, in which *grande* only had oviposited, failed to furnish adults of any sort, and straws taken from the fields gave only wingless females of *tritici*, which, as usual with those reared in mid-winter, refused to oviposit on wheat plants grown and kept indoors for that purpose. On returning from the South in April, however, we found a limited number of these *tritici*, which had emerged much later, probably in March, alive in the breeding-cages, and at once transferred them to young wheat plants grown and kept continually under cover, in a corner of our garden, at least three-fourths of a mile from any field of either wheat, rye, or barley. This was on the 12th of April.

From this time forward until the grain and straw were fully ripened, early the following July, the utmost caution was observed in keeping the plants thoroughly protected from outside insects, and, with the exception of a single Tipulid, which appeared during spring, no insects whatever were at any time observed within the inclosure except the *Isosoma*.

On the 2d of June, fifty-one days after the *tritici* had been placed in the inclosure, a female of *grande* was observed in the act of ovipositing in the now nearly full-grown straw, and within the next few days several others were noticed similarly occupied, placing their eggs not only in the upper joint, but in the one below also. Previous to this, and, in fact, since the 21st of May, the latter species had been observed continually in the fields, and the belated appearance of these in the inclosure is perhaps due to the fact that their progenitors, the *tritici*, were of the last to emerge in the spring. Absence from home for two months previous to the date of their removal from the breeding-cage to the young wheat made it impossible to secure them earlier, as it was difficult to get enough then living to carry on the experiments, the numerous dead in the cage indicating that the species had been emerging for some time.

As before stated, the *tritici* placed in the inclosure were all of them females. Neither could any males be found among those that had previously died, and, moreover, all of the *grande* were females apparently, as all that were observed at all in the inclosure were ovipositing. Hence the males of either form, if there are any, are still unknown to me.*

A winged form of *Isosoma*, seemingly intermediate between *tritici* and *grande*, was taken with the latter in considerable numbers about Bloomington, Ill., during May, 1884, and has since been found in the vicinity of La Fayette, Ind., in both grain fields and grass lands, but in too limited numbers to permit of successful

* As shown on page 544, we have been more successful in this respect than has Mr. Webster, and three males of *tritici* were bred in January, 1886.—C. V. R.

rearing in confinement, and hence what affinities it may have with other forms or species is not known.

A small form of *hordei* also occurred about La Fayette during the latter part of May, 1885, on blue grass and timothy, growing up intermixed, and also to a very limited extent on wheat; but this also refused to oviposit in the latter in the breeding-cages, and disappeared from the field of both grain and grass altogether in a few days.

The same locality was repeatedly swept over during the present season, but no *hordei* could be found. *Grande* were, however, obtained in considerable numbers from grass lands, but the most careful search failed to reveal any indication that they emerged from these grasses or that they oviposit in them.

It may be proper to state here that in the three years during which I have had these Isosomas under observation they have never been observed ovipositing in chess, nor has an instance been noticed where the straws of this grass have been affected by them. This discrimination on the part of these insects, whereby the stools of wheat are prevented from heading, while those of the grass continue to flourish, may perhaps in part account for the unexpected preponderance of the latter during some seasons, a phenomenon which so sorely taxes the science of the unbotanical farmer.

There is, however, a species of larva infesting the stems of timothy from the latter part of July to the following spring whose method of work is very similar to that of the wheat-straw worms, but which nevertheless belongs to a different order of insects. It is probably the larva of a species of *Languria*,* and may readily be distinguished by the form of the head, by the more slender and less smooth body, and by the presence of well-developed legs on the thoracic segments.

THE AMERICAN MEROMYZA.

(*Meromyza americana* Fitch.)

Full-grown larvæ of this species were observed by us on June 18 of the present year in a field of rye near Kentland, Newton County, Indiana, and we bred adults from straw grown near La Fayette about July 21, and again from volunteer wheat in the same field from which the straw had been taken from September 3 to 21. A previous examination of this field made August 31 had revealed the fact that the volunteer wheat plants growing upon a space 1 foot square contained 11 puparia, 1 empty case, and 1 two-thirds grown larva.

On October 5 we found adults in great numbers (and also adults of a parasite, *Cœlinius meromyzœ* Forbes) engaged in ovipositing on wheat in a field sown September 22, and on going to another field, which had been sown much earlier, we found adults there also, but in less numbers, although the former field had been sown on oat stubble, while the latter field had last produced a crop of wheat.

In view of these observations and the results of your own breedings from volunteer wheat sent you from Oxford, Ind., on September 6, 1884, there seems little reason to doubt the existence of a third brood of flies, originating, largely at least, in volunteer grain, and emerging therefrom during the month of September.

As we have elsewhere shown,† the observations of Fitch, Riley, Lintner, Forbes, and ourself in no case have indicated that a third brood was improbable, but in some instances strongly presage its existence.

THE COMPANION WHEAT-FLY.

Oscinis (?) sp.

During the latter part of June, 1884, while examining wheat straws in which the larvæ of *Meromyza americana* were at work, we often found several smaller larvæ, also dipterous, and so closely associated with the former that we at first suspected them of being parasites. They were almost invariably found among the juicy mass of substance that had been displaced by their larger consort.

Securing a supply of affected straws, we cut from each a section about 3 inches

*Specimens of this larva were forwarded to us by Mr. Webster, but the adult beetle was not bred. The larva was indistinguishable from that of *Languria mozardi*, described by Professor Comstock in the Annual Report of this Department for 1879 under the popular name of "The Clover-stem Borer," as he had reared it from stems of Red Clover at Washington. Mr. Webster's larvæ probably belong to this species, which is figured on Plate I, Fig. 6, of the report just cited, and described on page 199.—C. V. R.

† Bulletin No. 9, Purdue University, issued October, 1886.

long, including the upper joint, but excluding the head, and placed them in a breeding jar. The result was, when the adult *Meromyza* emerged from these sections, July 18 to 23, there appeared among them quite a number of a much smaller black species, closely resembling those of the genus *Oscinis*, but, however, being quite distinct.

Early in the following September larvæ, seemingly like those observed in the straw, were found feeding within the stems of young volunteer wheat plants, and later the same thing was observed to destroy young plants in a field of early sown wheat.

From this volunteer wheat adult flies of the species now under consideration emerged from September 7 to October 1. The present season they began to emerge August 30, in both cases being the most numerous about the 10th of September. We have also reared adults from larvæ in wheat sown during the last week of August, these emerging as late as the 3d of October. The adults are common in wheat fields after about September 10 until the 1st of October, and hover about the young plants, doubtless for the purpose of ovipositing, as they are often observed pairing.

We have never observed them during late fall or early spring. They are sometimes attacked by a fungous parasite very similar to, if not identical with, that attacking the house-fly.

The larvæ are much smaller than those of *Meromyza*, but in a general way resemble them in form and color, particularly when the latter are only partly grown.

The puparia are, however, very different, being only about 2.5^{mm} long and 0.8^{mm} broad. The color is never like that of *Meromyza*, being at first of a yellowish-white, with tinge of green, but later changing to a uniform brown. They are readily distinguished from those of the Hessian fly by being cylindrical and by the segments being well defined.

From the foregoing it will be observed that, so far as we have been able to study the species, its cycle is exactly parallel with that of the *Meromyza*, and besides, there is a strong probability that while in young wheat the larvæ work independently, in the full-grown straws, where the tissue is too tough for their less rugged mouth parts, they become the mess-mates of their stronger consort, and feed from the vegetable juices by which it is surrounded. It is this characteristic that suggested the common appellation selected.

The damage done to young wheat in the fall by this species must be considerable, the credit thereof falling upon the *Meromyza*, as the effect of the two larvæ is exactly the same.

INSECTS AFFECTING BARLEY.

On account of the limited area sown, we have had but little opportunity to study the insect enemies of this cereal, but it is extremely probable that the species do not differ greatly from those depredating upon the closely allied grains—wheat and rye.

The two species here mentioned were observed in a small plot of this grain on the University experiment farm, which had produced nothing but barley for the last five or six years.

THE WHITE GRUB.

(*Lachnosterna fusca* Fröhl.)

These well-known depredators were observed during the present season engaged in cutting off the roots of the full-grown and fully-headed grain. As late as the 28th of June they were causing whole stools of the straw to wither and dry up before the kernels had filled.

THE BARLEY ROOT-LOUSE.

(*Schizoneura* sp.)

Both winged and apterous individuals were found clustering on the roots of barley in this same plot on the 12th of June, 1885, and at that time seemed to be doing considerable injury, but we were unable to secure an above-ground form.

The present season we found the same species in the same place but several days earlier, and watched them continuously until the 15th of July, when a few individuals might still be found upon the roots, although the grain was fully matured. Again we failed to secure an aereal form, although the grain was kept under careful inspection until harvest, nor could we rear any such in a breeding-cage, to which we had transferred infested barley plants.

In the fields the lice were all attended by ants, as usual, and, when placed in the breeding-cage without their protectors, seemed to be well-nigh helpless.

THE GRAIN APHIS.

(*Siphonophora avenæ* Fab.)

This species was observed infesting the heads of barley in considerable numbers, and, when the grain was fully ripe and the winged adults ready to forsake the barley heads, we placed some of them in cages in which growing timothy, blue-grass, and red-top had been transplanted, with the hopes of learning where the species passed the summer or until the young wheat appeared in the fall. The grasses were kept alive, but the insects died, and no trace of a following generation was observed.

INSECTS FREQUENTING OR DEPREDATING UPON BUCKWHEAT.

So many reports of the aversion of insects for this plant are going the rounds of the press, nearly all of which are unaccompanied by generally accepted authority, that some exact data relative to the matter seems very desirable. It was with a view of obtaining this information that, under Dr. Riley's instructions, we began a series of observations, selecting as a basis one of the experiment plots of the University farm, which for the past five years has grown nothing but buckwheat, thereby eliminating at the start any insects that might have been attracted by a previous crop of grain or grass and remained over in either the adult or adolescent stages.

As the object of the observations was a twofold one, *i. e.*, to learn both the repulsive and the direct and indirect attractive properties of the growing plant, what may at first appear to be overexactness will at once be seen to be quite essential, as the occurrence of an insect but once or twice during several weeks is strongly indicative of a repugnance for the locality.

Observations began as soon as the plants were well above the surface of the ground, and, until they were high enough to sweep with an insect-net, consisted of careful inspection only, but later the entire plot was swept over at intervals of a few days and a record kept of all captures. As some species visit the plants at one time of day and others at another, the time of sweeping was varied, in order to preclude the possibility of any escaping notice in that way. These observations were carried on until frost destroyed the plants.

In the table the symbol "A" signifies abundant; "C," common. Where only very few examples occurred their number is indicated numerically. Unless otherwise stated the adult stage is intended, and where a * follows the name of insect the larval state only is intended; if a †, the pupal. When these follow the other symbols, A or C, it is to be understood that all states occur, adults preponderating. If they precede the letter, all states occurred in numbers indicated. Thus A * †, adults abundant, larvæ and pupæ; * † C, all stages common.

List of insects.

Insects.	Aug. 4, p. m.	Aug. 17, p. m.	Aug. 18, a. m.	Aug. 20, 9.20 a. m.	Aug. 24, 4 p. m.	Aug. 28, 4 p. m.	Aug. 31, 10.20 a. m.	Sept. 3, 1.20 p. m.	Sept. 7, 10 a. m.	Sept. 11, 3.30 p. m.	Sept. 14, 9.15 a. m.	Sept. 20, 12 m.	Sept. 25, 2.30 p. m.	Oct. 1, 2 p. m.
Apis mellifica Linn	....	....	....	C	....	....	A	....	A	...	A	A	....	....
Bombus sp	....	....	....	....	....	....	....	....	1	....	2	....	....	....
Cerceris compactus Cr	1	....	....	....	....	....	....	....	....	....	....	....	....	....
Halictus flavipes (Fabr.)	....	C	....	....	....	....	2	....	....	1	1	....	....	....
Halictus sp. ? (No. 19)	....	C	A	A	....	....	C	....	C	....	....	....	....	....
Sphex pennsylvanicus Linn	1	....	....	....	....	....	1	....	1	....	2	....	....	....
Ammophila uruaria Dahlb	....	....	....	....	1	....	....	....	....	2	....	1	....	1
Pompilus sp	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Tiphia (near) *inornata* Say	....	....	....	....	....	....	1	....	....	....	....	....	....	....
Tiphia sp. ?	....	C	C	C	....	C	1	....	....	....	....	2	....	....
Myzine harnata Say	....	1	....	2	....	....	2	....	A	....	1	3	....	....
Mutilla (near) *fenestrata* St. F	....	1	....	....	....	....	....	....	....	....	1	....	....	....
Lasius flavus	C	C	C	C	C	C	C	....	C	A	A	A	....	2
Perilampus (near) *hyalinus* Say	....	....	....	2	C	2	A	A	A	A	A	A	C	1
Formica schaufussii	3	C	C	C	C	C	A	3	A	A	A	C	....	3
Caliopsis andreniformis Say	....	C	....	1	....	....	1	....	....	C	....	....	....	....
Cynipid sp. ?	....	....	....	....	C	C	A	....	....	C	C	....	....	....
Agathis sp. ?	....	1	....	....	....	....	....	....	....	....	2	....	....	....
Mesograpta marginata Say	....	....	....	....	....	....	....	....	1	....	C	....	....	....
Pieris protodice Bd	....	....	....	2	....	....	2	1	C	C	A	A	C	....
Colias eurytheme Bd	....	....	....	....	....	....	....	....	C	....	1	2	....	....
Danais archippus Fab	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Pyrameis atalanta Linn	....	....	....	....	....	....	....	....	1	....	....	1	....	....
Pyrameis cardui Linn	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Deilephila lineata Fab.*	....	....	....	....	....	....	1	....	3	....	1	2	2	....

List of insects—Continued.

Insects.	Aug. 4, p. m.	Aug. 17, p. m.	Aug. 18, a. m.	Aug. 20, 9.20 a. m.	Aug. 24, 4 p. m.	Aug. 28, 4 p. m.	Aug. 31, 10.20 a. m.	Sept. 3, 1.20 p. m.	Sept. 7, 10 a. m.	Sept. 11, 3.30 p. m.	Sept. 14, 9.15 a. m.	Sept. 20, 12 m.	Sept. 25, 2.30 p. m.	Oct. 1, 2 p. m.
Acronycta oblinita A. & S.*	....	....	....	....	....	....	....	....	....	....	1	....	....	....
Acontia erastoides Guen	....	....	....	2	C	A	C	C	C	C	C	C	....	....
Geometrid larva	....	....	....	....	1	....	....	....	....	....	....	....	....	....
Crambus (near) *fuscicostella* Zell. (No. 13)	1	....	....	....	....	....	....	....	....	....	....	....	....	....
Dichœlia sulphureana Clem.*	....	....	....	....	2	1	1	1	....	....	....	....	....	....
Eurycreon rantalis Guen	....	....	3	C	A	A	A	A	A	C	C	C	2	....
Cicindela punctulata Fab	C	C	C	C	C	C	C	C	C	C	3	1	1	1
Harpalus pennsylvanicus Dej	....	....	....	....	....	....	....	1	1	....	....	....	....	....
Tachyporus brunneus Fab	....	....	....	1	....	1	....	1	....	C	....	....	....	....
Sylvanus advena Waltl	....	....	....	....	....	....	....	....	....	1	....	....	....	....
Corticaria pumilis Mels	....	....	....	2	....	....	....	....	C	C	1	C	C	C
Hippodamia convergens Guen	....	....	....	....	....	....	....	1	....	....	....	....	....	....
Hippodamia parenthesis Say	....	....	....	....	....	....	....	....	1	....	2	....	....	....
Cycloneda sanguinea Linn	....	....	....	....	....	....	1	....	....	....	1	....	....	....
Coccinella 9-notata Hb	....	....	....	....	....	....	1	....	....	....	1	....	....	....
Chauliognathus pennsylvanicus Först	....	....	....	2	C	C	C	C	A	C	C	C	1	....
Ditemnus bidentatus Say	....	....	1	....	....	....	....	....	....	....	....	....	....	....
Cyphon variabilis Thunb	....	....	....	....	....	....	....	....	....	....	1	....	....	1
Bruchus obsoletus Say	....	....	....	....	....	....	1	....	....	....	1	2	1	....
Colaspis brunnea Fab	A	A	A	C	....	1	....	2	1	....	1	....	....	....
Doryphora 10-lineata Say	....	....	1	....	....	....	....	....	....	....	....	....	....	....
Chrysomela suturalis Fab	....	....	....	....	....	....	....	....	....	....	....	2	....	....
Diabrotica 12-punctata Oliv	....	....	....	....	2	....	....	1	1	2	2	2	1	....
Diabrotica vittata Fab	....	....	....	....	....	....	....	....	....	....	....	1	....	....
Diabrotica longicornis Say	....	....	C	C	A	A	A	A	A	A	A	A	C	2
Disonycha punctigera Lec	....	....	....	....	....	....	....	....	C	....	....	2	....	....
Longitarsus testaceus Lec	....	....	....	....	....	....	....	....	....	....	2	....	....	....
Phyllotreta vittata Fab	....	....	....	....	2	1	....	....	....	....	....	....	....	....
Systena frontalis Fab	....	....	....	....	....	1	....	....	....	....	....	....	....	....
Systena blanda Mels	....	....	....	1	....	....	....	....	....	....	1	....	....	....
Crepidodera atriventris Mels	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Chætocnema confinis Cr	....	C	A	A	....	A	A	1	C	....	1	C	C	1
Mordella octopunctata Fab	....	1	....	....	....	....	....	....	....	....	....	....	....	....
Epicauta vittata Fab	A	C	A	C	C	....	1	2	1	....	....	....	....	....
Epicauta lemniscata Fab	A	A	A	C	2	1	....	2	1	....	1	....	....	....
Epicauta cinerea Först	3	....	....	....	....	....	....	....	....	....	....	....	....	....
Epicauta pennsylvanica De G	....	....	....	....	1	....	....	....	....	....	....	....	....	....
Centrinus picumnus Hort	....	....	....	....	....	....	....	....	....	....	....	....	....	2
Sphenophorus parvulus Gyll	....	1	....	....	....	....	....	....	....	....	....	....	....	....
Sciara sp. ? (No. 31)	....	....	....	1	C	C	A	A	A	A	C	C	C	....
Bibio sp. ? (No. 82)	....	....	....	....	....	....	....	....	2	2	....	....	....	....
Anthrax sp. ?	A	C	1	....	....	....	....	....	....	....	....	....	....	....
Sparnopolinus sp. (No. 14)	1	C	....	....	....	....	....	2	....	C	....	....	....	....
Stratiomyia sp. ? (No. 87)	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Oscinis sp. ? (No. 26)	....	1	....	3	2	C	C	C	3	C	C	C	C	....
Oscinis sp. ? (No. 64)	....	....	....	....	C	C	A	....	....	C	C	....	....	....
Chlorops sp. ? (No. 65)	....	....	....	C	A	A	A	A	A	A	A	A	A	C
Meromyza americana Fitch	....	....	....	....	....	....	1	C	C	1	2	C	C	1
Syritta pipiens Macq	....	....	....	....	....	....	....	....	....	....	C	C	2	....
Oncomyia sp. ? (No. 89)	....	....	....	....	....	....	....	....	....	1	....	....	....	....
Chelonus sericeus Say	....	....	....	....	....	....	....	....	....	....	1	....	....	....
Aphis sp. ? (Root-form)	....	....	....	....	....	....	C	C	C	C	C	....	....	....
Dactylopius n. sp. ?	....	....	....	....	....	....	C	....	....	....	....	....	....	....
Jassus inimicus Say	....	....	C	C	C	C	C	C	C	C	1	C	3	2
Macropsis venatus Uhl	....	....	C	C	C	C	C	C	....	C	1	C	....	....
Actualis calva Say (var.)	....	....	....	....	....	....	....	....	....	1	....	....	....	....
Diedrocephala mollipes Say	....	....	....	....	....	....	....	....	....	....	1	1	....	....
Euschistus servus Say	....	....	....	....	....	....	....	....	1	....	....	....	1	....
Corizus lateralis Say	....	....	....	1	....	....	1	....	....	1	2	C	C	....
Blissus leucopterus Say	....	....	....	....	....	....	C	1	....	....	....	....	....	....
Geocoris limbatus Stäl	1	....	....	1	C	1	....	....	....	....	....	....	....	....
Lygus pratensis Linn	....	C	A	C	A	A	A	A*	A*	A*†	*†A	A*†	A*†	A
Calocoris rapidus Say	....	....	....	....	....	2	C	C	C	C	C*	C*	*†C	1
Plagiognathus obscurus Uhl	....	1	1	C	C	C	1	....	C	2	1	1	....	....
Plagiognathus sp. ? (No. 24)	....	1	3	....	....	1	2	....	C	A	C	....	2	....
Agalliastes sanvis Reuter	....	1	1	....	2	....	....	C	3	C	C	....	....	....
Triphleps insidiosus Say	....	A	A	A	A	A	A	A	A	A*	A*	A*†	C*†	2
Corius ferus Linn	....	....	....	....	2	C	....	1	....	1	2	C	C*	....
Acholla multispinosa De G	....	....	....	....	....	....	....	2	1	....	1	1	1	....
Coleothrips 3-fasciata Fitch	....	....	....	C	C	C	C	A	A	A	C	3	2	....
Œcanthus niveus	....	....	....	....	....	1	3	....	....	....	....	2	....	....
Orchelimum vulgare Harr	....	....	....	....	....	1	....	1	....	1	....	....	....	....
Gryllus abbreviatus	C	C	C	C	C	C	C	C	C	C	C	C	3	1
Melanoplus femur-rubrum Harr	A	A	A	A	A	A	A	C	C	C	C	C	C	C
Œdipoda carolina Linn	....	....	....	....	....	....	1	....	2	1	....	....	1	....
Crysopa externa ?	....	....	....	....	....	....	2	1	C	....	2	C	C	....
Smynthurus sp. ?	....	....	....	....	....	3	....	C	A	A	A	C	....	....

The Hymenoptera, as a rule, occurred most abundantly during the forenoon. Of the *Lepidoptera*, *Acontia* and *Eurycreon* were the most abundant. *Dichelia* was reared to the adult, but the *Geometrid* larva died, and it is very doubtful if this was really one of its food-plants.

The rarity of *Carabidæ* is quite suggestive as being in accordance with the lack of earth-inhabiting larvæ, and likewise the dearth of *Coccinellidæ* might be traced to the lack of *Aphididæ*. *Bruchus obsoletus* doubtless wandered from a plot of beans near by. *Colaspis brunnea* fed upon the buds. The lack of *Doryphora* was strongly indicative of disgust for the plant, as the adjoining plot was planted to potatoes, which they destroyed, and migrated to other localities, but studiously avoided the buckwheat. The same was true of *Epicauta*, excepting the *vittata* species, which fed upon the foliage quite freely. *Diabrotica longicornis* was one of the most abundant insects, and fed upon the blossoms. *Aphis* sp. ? and the *Dactylopius* were both found upon the roots. The spasmodic occurrence of *Blissus leucopterus* has the same signification as the single occurrence of *Doryphora*. *Lygus pratensis* was one of the most abundant species, and at the time of the last two observations it outnumbered all others ten to one. *Melanoplus femur-rubrum* seriously injured some of the young plants, but only along the margins. *Gryllus abbreviatus* cut off the plants and dragged them into its burrows, but only for about the first week after they came up. Larvæ of *Chrysopa* were quite numerous during August and September. Possibly these were of the same species as the adults. The *Anthrax* emerged from pupæ in the soil in considerable numbers during the early part of August.

Besides these, Dr. Riley (First Mo. Rep., p. 79) states that the larvæ of *Agrotis clandestina* and (Third Mo. Rep., p. 109) *Laphygma frugiperda* (*Prodenia autumnalis*) affect this plant, as also (Seventh Mo. Rep., p. 159) *Melanoplus spretus*. Dr. Cyrus Thomas (Sixth Ill. Rep., p. 171) thinks *Gastrophysa polygoni* might attack the plant, but we found nothing of the species in this case. In Riley's Seventh Mo. Rep., p. 43, a correspondent states that *Blissus leucopterus* did not affect his corn where buckwheat was sown among it. *Deiliphila lineata* (larva) is recorded as feeding upon this plant by Dr. Riley in Third Mo. Rep., p. 141.

INSECTS AFFECTING TIMOTHY.

THE GLASSY CUT-WORM.

(*Hadena devastatrix*, Brace.)

On June 29 of the present season Mr. J. G. Kingsbury, of the *Indiana Farmer*, called our attention to some rumors which had reached him relative to the depredations of some kind of worm in the timothy meadows about Richmond, Wayne County, Indiana, and we immediately wrote Mr. J. C. Ratliff, of Richmond, from whom, on the 12th of July, we received a reply fully corroborating the reports given us by Mr. Kingsbury.

On the 15th, in accordance with instructions from Mr. Howard, entomologist in charge, we visited the infested fields, three in number, situated to the northwest of the city, one on the grounds of the insane asylum, another about a half a mile north of this on the farm of Mr. Kreets, and the third on the farm of Mrs. Thompson, perhaps 2 miles farther to the northwest.

The field on the grounds of the asylum, of which about 15 acres were totally destroyed, had been plowed and planted with corn after the ravages had ceased, but the other two fields, of which about 15 and 20 acres, respectively, had been destroyed, remained intact. A critical examination of the affected portions of these two fields revealed the fact that even where every vestige of timothy had been destroyed red clover remained untouched, and a decided preference had been evinced for low, damp localities.

In the Thompson field chrysalids were found quite abundantly within a couple of inches of the surface; and with them, in almost equal numbers, were the larvæ of *Hadena devastatrix*, some of which were already in frail earthen cells, preparatory to pupating, all of these last being of a dingy-white color, with yellow heads. Interspersed among the *Hadena* larvæ were a very few of *Nephelodes violans*. In the Kreet field both chrysalids and larvæ were much less abundant, although the destruction had been equally complete. Here also the *Nephelodes* larvæ were found, but in a still smaller ratio as compared with those of the *Hadena*.

To settle any doubt which might arise as to which of the two species of larvæ were the authors of the destruction, we questioned the owners of the fields very closely, as well as the employés on the two farms, but all stated that the striped larvæ had

never been numerous, and that it was the white ones with brown heads ("about half way between a worm and a grub," as they expressed it) which did the injury. In fact, an aged and intelligent gentleman, Mr. Vinnedge Russell, as soon as he learned of our arrival, went to the Thompson field and brought us therefrom a number of *Hadena* larvæ, remarking that the striped worms had occurred with them, but only in very limited numbers, and that those brought were the depredators.

From what we were able to learn, the effect of these worms was noticed for the first about the middle of May, and they continued to carry on their work for about three weeks, after which they appeared to do no injury, and the dried remains of the young grass seemed to attest to the statement, as in no case were any withered or dead clumps observed. The destruction appeared to lie solely in the amputation of the small roots, neither the bulb nor the blade having been ravaged, and we were informed that the worms were in no case observed feeding above ground, but invariably below the surface.

Although no such outbreak of these larvæ in meadows had been previously recorded, this habit of feeding below ground, and upon the roots of grasses was noticed long ago by Dr. Riley, who found that the larvæ would bury themselves in the earth, and feed in this manner from grass roots, although other food was provided them.*

That the *Hadena* larvæ, in both the Thompson and Kreet fields, originated in each case in excessive numbers throughout only a very limited area, and that they gradually extended their domains as the food-supply became exhausted, was very evident. In the Kreet field, which was very low, flat, and damp, the depredations began in the southwest corner, the worms gradually working eastward parallel with the highway, which was carefully avoided, and a margin of grass six to ten yards wide was left almost untouched, while they pushed farther and farther to the northward for a considerable distance, destroying every vestige of timothy, gradually seeming to exhaust themselves near the northern and eastern boundaries of the field.

In the Thompson field they originated in the northwestern portion, along a low, wide ravine, traveling eastward, following a narrow ravine near the northern boundary, a tributary of the former, nearly across the field, while elsewhere along the line of origin they did not extend their depredations more than about one-third as far, as that direction brought them upon the higher ground.

We were informed that while a few worms had been observed working upon the higher grounds in this field little damage had been done there, but as the tributary ravine reached high ground there had been a tendency to spread out at right angles, those on the south side being, as it were, thrown across the path of those worms proceeding east from the place of origin. As in the Kreet field, the boundary between the totally destroyed portion and the uninjured was irregular and poorly defined, a gradual fading of one into the other.

In this field larvæ and pupæ were found in considerable abundance, although many of the former did not appear in a healthy condition, and many of the latter had a blackened look, and some others had evidently been destroyed by some natural enemy. But in the Kreet field the case seemed different, for here it required considerable labor to obtain either larvæ or pupæ, even in limited numbers, and many of these were affected as in the Thompson field. Dead larvæ were found in the earth, stretched at nearly full length, rigid, and with a parasitic fungus, a species of *Isaria*, growing from between the thoracic segments, but more frequently from the neck, after the manner of *Torrubia* from the white grub, only that in this case they affect the upper as well as the under part. This was also observed to attack the larvæ of *Nephelodes violans*.

On July 17 a goodly number of larvæ and pupæ were secured from both fields and placed in earth in tin boxes. Returning home on the 19th, these boxes were at once opened, and found to be literally swarming with a species of *Pteromalus*. The larvæ and pupæ were placed in separate cages, the *Pteromalus* continuing to appear in that containing pupæ for several days afterward. Later there appeared from these pupæ a single individual of *Ichneumon jucundus*, a species of *Tachina*, and also a species of *Phora*. This last, however, was doubtless a scavenger and not a parasite.

The first moth appeared from the pupæ on the 22d, and the first appeared from the larvæ on August 11. All moths obtained were *Hadena devastatrix*, but not over 10 per cent. of the adolescent individuals developed to adults.

Had the appearance of the Glassy Cut-worms been more general, in such numbers as in the vicinity of Richmond, the loss would have been very serious; as it

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*First Report Insects of Missouri, p. 83, 1868. Report Commissioner of Agriculture, 1884, p. 297.

was, Mr. Ratliff, who is a crop correspondent of this Department, estimated the damage to the three fields at about $1,000.

We have not been able to learn of any such depredations elsewhere, and Messrs. A. W. Butler, of Brookville; Stephen Gardner, of Cottage Grove; S. S. Merrifield, of Connersville; and D. E. Hoffman, of Winchester, all located in Wayne and adjacent counties, have written us disclaiming all knowledge of any similar ravages.

While we were on the ground too late in the season to observe the working of these worms or carefully study their movements, both the appearance of the affected fields at that time and the information obtained were strongly indicative of a slow, migratory habit. Mr. Kreet stated that he had several times observed the worms collected in deep holes in the earth, from which they appeared to be endeavoring to escape. All of this is very suggestive of preventing the progress of the worms by ditching, or even plowing a deep furrow across their course, and destroying them as they accumulate in the bottom, as with the Army Worm.

We again visited the locality on October 30. The Kreet field had been plowed in the mean time, and was now covered with a luxuriant growth of wheat. The Thompson field remained as we had left it in July, but neither there nor in other meadows could we find any young Cut-worms of this species, although a few of other species were observed. We dug up the earth to a depth of several inches in places where it seemed most probable that they would occur, but found none.

We observed a considerable number of carnivorous larvæ in the Thompson field, and these, quite likely, aided in sustaining the check given the worms by the parasites of the spring brood.*

THE GRAIN SPHENOPHORUS.

(*Sphenophorus parvulus* Gyll.)

During the latter part of July of the present year the larvæ of this species were observed burrowing in the bulbs of timothy, their method of work not differing materially from what it was in wheat, as described in our last year's report, excepting that the bulb, being much larger than a straw, enabled the larva to attain to nearly or quite full growth before leaving it to pupate. Several larvæ were often found infesting a single stool. Pupæ were also found in the earth about these stools.

While examining the roots of timothy in meadows about Richmond, Wayne County, Indiana, on October 30, we found an adult of *Sphenophorus sculptilis* Uhl. in the midst of a mass of eaten bulbs, these last resembling in every particular those which had been destroyed by *S. parvulus*.

INSECTS AFFECTING WHITE CLOVER.

THE FLAVESCENT CLOVER WEEVIL.

(*Sitones flavescens* Allard.)

Early in the month of October, 1885, the foliage of White Clover (*Trifolium repens* L.) on the University grounds was found to be seriously injured by some insect depredator, and a plot of Alsike (*T. hybridum*) was likewise attacked, while Red Clover (*T. pratensis*) escaped with very little injury, even though growing up promiscuously among both of the former varieties.

This injury to the leaves of clover was of two patterns, one consisting of a circular disk extracted from the center and the other a more or less hemispherical portion taken from the margin, and, while there was never more than one circular space eaten from the same leaf, there might be several of the marginal pattern, or the two might be combined, thereby leaving only the leaf-stalk and bases of the mid-veins.

Careful search failed to reveal any insect about the injured plants in sufficient numbers to arouse suspicion, except a small, yellowish-brown curculio, *Sitones flavescens* Allard, an imported species, injurious to clover in Europe, but not previously known as such in America, although Dr. Riley had some years ago † directed atten-

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*One of these species of larvæ was that of an Elater, probably *Drasterius dorsalis* Say. The larvæ of this genus are known to be carnivorous, and we have observed this species destroying the larvæ of *Crambus zeellus* Fern., and also those of an undetermined species of *Macrops* which burrows in the roots of common plantain (*Plantago major* L.).—C. V. R.

† *American Naturalist*, Vol. XV, p. 751, and Report Commissioner Agriculture 1881, p. 177.

tion to its native habits, and Dr. Lintner had placed it in his list of possible enemies of the clover plant in New York.*

Dr. Le Conte† gives the species as inhabiting the Atlantic States in abundance, especially near the sea-shore, and states that the American race differs from the European by the color of the scales, being more rusty and less gray. We have for years found it plentifully here in the West, while Dr. E. R. Boardman reports both the beetles and their work in Stark County, Illinois, and Mr. Charles N. Ainslie, Rochester, Minn., makes a similar statement.

The beetles are rather timid, and, on being disturbed, drop to the ground and seek refuge among leaves and rubbish, and it was only after considerable patient watching that they were observed in the act of feeding upon the leaves. This they do by simply moving the head and thorax, the body remaining stationary, the circular disk being cut when the leaf is still folded, the two halves facing each other, the beetles eating through the back at the mid-vein. The half disk thus extracted from the two makes a full disk when the leaf is fully unfolded.

On October 17 a number of the beetles, confined alive in a small vial, deposited a number of eggs therein; and on the 25th of same month other adults, which had been placed in a breeding-cage with clover plants selected and transplanted from a locality where the leaves had not been injured, also oviposited, dropping their eggs about promiscuously, some being on the leaves, others scattered about on the surface of the soil, and one stuck to the side of the cage.

The eggs are nearly white, with a very slight tinge of yellow; slightly elongate, ovate, being a trifle less than 0.4^{mm} broad and a little more than 0.4^{mm} in length; not acuminated or depressed.

In a temperature of 65° F. these eggs hatched in about 48 hours after being deposited, the young larvæ at once disappearing. A few days later they could be found feeding upon the fresh lateral shoots, or even the softer parts of the main stem under the bases of the leaf stalks. The entire plant upon which the larvæ were confined withered and died within a few weeks, although it was kept well watered and under favorable conditions for growing.

A search in the fields about seriously injured plants revealed numerous small, white, footless larvæ in the earth, varying considerably in size, and for the most part much larger than those we had hatched indoors. None of the larvæ were observed in the act of feeding except one individual, a rather small one, which was engaged in devouring a seed. On being placed in glass tubes with stems of the plant they at once began to eat out the central portion, leaving only the epidermis. Similarly affected stems were quite common in the fields, but whether they were due to the work of this or another insect we find it still too much to say, although the former is the more probable, as there has been at no time anything to indicate that these larvæ attack the root, leaf, or leaf-stem portions of the plant, however near the latter might be to the surface of the ground.

Two larvæ found in the fields on the 1st of November being much larger than any previously observed, they were taken indoors and fed with stems of clover, upon the younger, tenderer portions of which they subsisted until the 2d of December, when one of them pupated, and twenty days later transformed to an adult, being at first nearly white, but assuming its normal color four days later. The second larva died before pupating.

The full-grown larva is 5^{mm} long; head small, testaceous, with brown mandibles; body white, wrinkled, first segment little larger than head, second and third larger, fourth to ninth nearly equal, gradually decreasing to thirteenth, which is very small and nearly pointed.

These larvæ when at rest in the earth lie in a hook-shaped position, the head and thoracic segments being kept at almost right angles to the fourth segment, where the rather abrupt curve begins. Prior to pupating they form a small earthen cell.

On December 9, the ground being frozen to the depth of from 2 to 2½ inches, affected plants, with the soil in which they were rooted, were dug up and brought indoors. After being thawed out this was carefully examined, and *Sitones* larvæ were found therein, varying in size from 1^{mm} in length to full grown, the major part being under 2.50^{mm} in length; but two fully grown were found, and these were in their cells preparatory to pupating. One larva, 1.50^{mm} long, began feeding as soon as thoroughly warmed. Two adults were also found, but no pupæ. One of these was kept in a breeding-cage, in a warm room, and was still alive on the 18th of the following February, when I left for an absence of a couple of months.

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*The Insects of the Clover Plant, Report N. Y. Agricultural Society, Vol. XL, for 1880. Author's edition, p. 4.

†The Rhynchophora of America north of Mexico, Proc. Am. Phil. Society, Vol. XV, No. 96, p. 115.

Besides these, two adults were observed in the fields, in the act of pairing, on the 12th of November.

On account of absence from home no examination was made until the 18th of April of the present year, when larvæ were again found in the fields, in less numbers but in about the same stage of development as during the previous December. No pupæ were observed, but two adults were found, which died soon after, without having in the mean time deposited any eggs.

On May 25 both larvæ and pupæ were found, the former in still less numbers than they were during April, but now they were, for the most part, nearly or quite full grown. An adult, taken also on this date, died on the 30th inststant without ovipositing. June 14 several adults were observed, and from this time forward they appeared in increasing numbers until August, when they seemed to reach the upward limit.

The deposition of eggs may commence in July, but we obtained none until August 7, and then only after keeping adults confined in the breeding-cage for four days; nor could we at this date observe any larvæ in plants in the fields, although very small ones were common enough in and about the tender lateral shoots early in September, but in no case were they burrowing in the main stem except in the tenderer portions, under the base of leaf-stalks, as previously indicated.

In summing up the life-history of the species, they may be said to emerge as adults as late as July, and deposit their eggs from the last of that month until cold weather begins. The larvæ, hatching within two days after the eggs are deposited, feed upon the tender portion of the clover stems, probably burrowing into them sometimes, especially when they are from one-fourth to one-half grown, and, barely possibly, subsisting in part upon the roots when older. They pass the winter, for the most part, in this stage, but occasionally as adults. The larvæ pupate in spring, and after remaining about twenty days in this state emerge as adults.

The adults seem to wander about considerably early in the season, and we have observed them traveling about on fences, upon the heads of grain, and crawling up the trunks of trees, and also found them hiding away under rubbish.

THE CLOVER-STEM MAGGOT.

(*Oscinis* sp.)

Sufficient opportunity has not been offered to study more than a portion of the probable cycle of this insect, yet the very deceptive resemblance between the work of the larvæ and those of *Sitones* renders some account of it almost a necessity in order to prevent confusion.

The adult insect is a small, rather robust, black fly. The individual larva is 4^{mm} long, with a breadth across the thoracic segments of $.6^{mm}$, footless, slightly diminishing posteriorly, with the division of the segments after the first three very obscure. Color yellowish-white, with a tinge of green, becoming nearly white at extremities; oral parts quite large and jet black. Near the posterior extremity is an abrupt ventral restriction, and on the rounded anal segment are two short, robust, brown processes, each terminating in a corolla of small circular pustules.

The puparium is 2.4^{mm} long and $.8^{mm}$ broad, elongate, oval, slightly tapering posteriorly, and rather less obtusely pointed than at anterior extremity. The two posterior processes are here reproduced, and two others, shorter and more widely separated, are placed on the anterior extremity. Color at first yellowish-white, with tinge of green, but later turning to brown, and from this to nearly jet black.

The insect was first observed by us on August 6 of the present year in the pupal stage, and within a stem of white clover, which had evidently been destroyed by it while in the larval stage. During the four succeeding days other puparia were found, but only two larvæ. From the puparia one adult emerged on August 12, others following a few days later, thereby indicating that the brood of which they were a part was rapidly approaching maturity.

The exact time and place of oviposition it was, of course, impossible to determine, but the maggots are found singly in the stem, sometimes just under the epidermis and sometimes in the center, but in either case excavating parallel channels, working from the point where the stem originated. Hence we are led to infer that the eggs are deposited near the main roots, and the larva, as its pushes forward, is provided with a continual supply of fresh-grown food, the terminal or growing portion of the stem being in part sustained by lateral roots thrown out at equal intervals. It is also possible that the eggs are sometimes placed on the young lateral stems, through which the maggots burrow their way to the main stem.

As yet we have no trace of more than the one brood mentioned, although it is not at all improbable that there may be several in a season.

REPORT ON EXPERIMENTS IN APICULTURE.

By N. W. McLain, *Apicultural Agent.*

LETTER OF TRANSMITTAL.

United States Apicultural Station,
Aurora, Ill., December 31, 1886.

Dear Sir: I have the honor to submit herewith my report of the work done under your instructions at this experiment station during the past year.

I desire to acknowledge my obligations to yourself for the valuable suggestions and assistance given me, manifesting the deep interest you have in advancing and developing the industry of bee-keeping.

I wish also to express my thanks to those engaged in the branch of husbandry in whose interest this experiment station was established for the very kind and unanimous expressions of appreciation and encouragement, some of whom have cheerfully aided me in my work; and especially to the publishers of the following apicultural and agricultural journals for the favor shown me in publishing my report and for files of their valuable papers, namely:

The American Bee Journal, Messrs. Thomas G. Newman & Son, Chicago, Ill.; *Gleanings in Bee Culture*, Mr. A. I. Root, Medina, Ohio; *The American Apiculturist*, Mr. Henry Alley, Wenham, Mass.; *The Bee-Keeper's Magazine*, Messrs. Aspinwall & Treadwell, Barrytown-on-Hudson, N. Y.; *The Bee-Keeper's Guide*, Mr. A. G. Hill, Kendallville, Ind.; *The Canadian Bee Journal*, Messrs. Jones, Macpherson & Co., Beeton, Ontario, Canada; *Rays of Light*, North Manchester, Ind.; *The Southern Cultivator*, Atlanta, Ga.; and *The Cultivator and Country Gentleman*, Messrs. Luther Tucker & Son, Albany, N. Y.

Yours, very truly,

N. W. McLAIN,
Agent in Charge.

Dr. C. V. Riley,
Entomologist.

THE "QUAKING DISEASE."

When bees are unable to obtain from ordinary sources a supply of saline and alkaline aliment, indispensable to their health and vigor and to the normal performance of their functions, they seek a supply from any available source. At such times they throng upon the Milkweed and Mullein, which exude a salty sap. At such times large numbers of dead bees may be found at the foot of the mullein stalks, and thousands perish in the fields, and thousands more which reach their hives, being low in vitality and unable to free themselves from the meshes of the silken fiber in which legs and wings are bound, die in the hive or crawl forth to perish. The actions of these starved and weakened bees when attempting to rise and fly or to rid themselves from the mesh of silky web causes a peculiar nervous motion, and this is one manifestation of that which is called the "quaking disease," or the "nameless disease." If examined with a microscope, many are found entangled with the filaments from the plants, and their stomachs are entirely empty.

The honey from hives containing colonies so affected has a peculiar and very disagreeable taste and odor, somewhat like that of fermented honey, indicating that some constituent essential in conserving it was lacking, and the cell-caps are dark, smooth, and greasy in appearance, and an offensive odor is emitted from the hive. An analysis of honey taken from such colonies, made by the Chemist of the Department, fails to reveal what element is lacking.

I have treated a number of apiaries so affected, using an application of strong brine, to which was added soda sufficient to make the alkaline taste faintly discernible. The hive should be opened, and each frame should be thoroughly dampened with spray from an atomizer, or the warm brine may be applied by using a sprinkler with very small holes in the rose, care being taken to use only enough to thoroughly dampen the bees and combs. The alighting-boards also should be thoroughly wet. The treatment should be applied morning and evening until the disorder disappears, which is usually in three or four days; a decided improvement being usually noticeable in twenty-four hours. The honey should be extracted and diluted by adding the brine, and, after being nearly heated to the boiling-point for ten minutes, may be safely fed to bees. The apiaries were last winter supplied with this food alone. Both wintered well. Vessels containing brine should always be kept in or near the

apiary. Pieces of burnt bone or rotten wood should be kept in the vessels of brine, and these vessels should be protected from the rain.

Another form of the so-called "quaking disease" appears to result from hereditary causes; for, if the queen be removed from the colony in which the disorder prevails, and a young, vigorous queen be substituted, in due time the disorder disappears. In very rare instances bees also gather poisonous nectar from plants, such as Fox-glove or Digitalis, the eating of which, it is reported, results in paralysis; another manifestation of the so-called "nameless disease."

THE FOUL-BROOD DISEASE.

One of the most maligant diseases incident to bees is called the "foul-brood" disease. What pleuro-pneumonia and hog-cholera are to the dairyman and swine-breeder foul-brood is to the apiarist. This disease is so stealthy and so virulent and so widely distributed, no locality in the United States being assured of immunity, that much apprehension is felt, and some of the States have enacted laws having for their object its control and extirpation. In many States the ravages of this scourge have resulted in ruinous losses to bee-keepers, and many on this account have been deterred from engaging in this profitable branch of husbandry.

During the past year I have given much attention to the study of this disease and to experiments for its prevention and cure. In making my investigations and experiments concerning the origin and nature of this disease and the means for its prevention and cure, I have collected a great amount of information from my own experience and from the experience of many others. Concerning the origin of this disease and its means of communication the evidence obtained is somewhat conflicting.

That the disease is actively contagious appears certain. That it is always communicated through the commonly accredited agencies is uncertain. That the disease is persistent and usually reproduces itself whenever the germs find the proper conditions for development is verified by experience. That the germs of this disease may be carried upon the clothing of the apiarist and in and upon the bodies of bees from one apiary to another, and that they may be borne by the wind from one hive to another in the same apiary, and that the disease germs may be liberated from the decomposing bodies of other insects and scattered over other objects with which the bees come in contact, seem probable.

That the disease is destructive to bees as well as brood, that live pollen is the medium through which the contagion is most commonly and most rapidly spread, and that the disease yields readily to treatment which is simple, cheap, and easily applied, appear to be true, in support of which I submit the following detailed account of my experiments and observations:

On the 1st day of June an apiarist having over two hundred colonies in his apiary reported to me that he had discovered two cases of malignant foul-brood, and that unmistakable evidences of its presence were apparent in twenty-five other colonies. As I knew this man was not without experience with this disease, I could not hope that he was mistaken. I knew that he had had unenviable opportunities, having been a bee-keeper for many years where this disease had been prevalent, and two years ago he himself had consigned one hundred and forty-eight colonies to the flames as incurable. I at once gave him the following formula for a remedy:

To 3 pints of soft water add 1 pint of dairy salt. Use an earthern vessel. Raise the temperature to 90° F. Stir till the salt is thoroughly dissolved. Add 1 pint of soft water boiling hot, in which has been dissolved 4 tablespoonfuls bicarbonate of soda. Stir thoroughly while adding to the mixture sufficient honey or sirup to make it quite sweet, but not enough to perceptibly thicken. To ¼ of an ounce of pure salicylic acid (the crystal) add alcohol sufficient to thoroughly cut it (about 1 ounce), and add this to the mixture while still warm, and when thoroughly stirred leave standing for 2 or 3 hours, when it becomes settled and clear.

Treatment.—Shake the bees from the combs and extract the honey as clearly as possible. Then thoroughly atomize the combs, blowing a spray of the mixture over and into the cells, using a large atomizer throwing a copious spray; then return the combs to the bees. Combs having considerable quantities of pollen should be melted into wax and the refuse burned. If there is no honey to be obtained in the fields, feed sirup or the honey which has just been extracted. If sirup is used, add 1 ounce of the remedy to each quart of the sirup fed. If the honey is used, add 2½ ounces of the remedy to each quart of honey fed. The honey and sirup should be fed warm and the remedy thoroughly stirred in, and no more should be furnished than is consumed.

Give all the colonies in the apiary one copious application of the remedy, simply setting the frames apart so that they may be freely exposed to the spray. This

treatment frequently reveals the presence of disease where it was not before possible to detect it. The quantity prescribed, applied by means of a large atomizer, is sufficient to treat one hundred and fifty colonies. Continue the treatment by thoroughly and copiously spraying the diseased colonies at intervals of three days, simply setting the frames apart so as to direct the spray entirely over the combs and bees. In order to keep the bees from bringing in fresh pollen, burn old dry bones to an ash and pulverize in a mortar and sift through a fine wire-cloth sieve, and make a mixture of rye flour and bone flour, using three parts of rye flour to one of bone flour, adding enough of the sirup or medicated honey to make a thick paste. Spread this paste over part of one side of a disinfected comb, pressing it into the cells with a stiff brush or a thin honey-knife, and hang this in the hive next to the brood. Continue this treatment until a cure is effected. Keep sweetened brine at all times accessible to the bees, and continue the use of the rye and bone flour paste while the colonies are recuperating.

As a preventive apply the remedy in the form of a spray over the tops of the frames once every week until the disease has disappeared from the apiary.

On June 20 the apiarist above referred to reported as follows:

"Number of colonies in the apiary June 1, 210. Number of colonies apparently diseased, 25. Treatment applied as directed to the whole apiary. Number of colonies actually diseased, 63. The disease present in all stages of progress; in some cases just appearing, in some well developed; in others the contents of the hives were a black mass, the brood combs nearly rotten, not an egg to be seen, and every cell of brood dead, and the stench from the hives nauseating. Have given the diseased colonies three applications, the first time extracting the honey. Effect of treatment instantaneous even upon apparently hopeless cases. Every colony save 5 is entirely free from any trace of disease, and these 5 are responding to treatment rapidly. I examined a colony to-day which two weeks ago had combs of brood almost rotten. No trace of the disease remains. I had 4,000 frames of extra comb. After hiving a few swarms, on some of them I found the disease present in every case. I then melted every one of these extra combs into wax, cleared and scalded and disinfected every hive, and hived the swarms on frames filled with comb-foundations. One of my neighbors, having an apiary of 60 colonies, had 38 cases of foul-brood, and before I was aware of it he had burned up a number of them. The remainder we treated as directed. His yard is now entirely free from disease. The cost of the remedy was just 10 cents. This prescription, if thoroughly applied according to your directions, will speedily and effectually cure the most hopeless and forlorn case of foul-brood."

It was afterwards found that the melting of the combs and scalding of the hives was not necessary.

After requesting this same apiarist to make some further tests, the nature of which will appear from what follows, August 1 he made the following report:

"In 5 of my best colonies, which had shown no symptoms of disease, I placed frames of brood from diseased colonies, treating them as I did the diseased colonies, and all evidences of disease speedily disappeared. To 1 colony from which the bees had swarmed out, leaving less than half a pint of bees between the black rotten combs and not an egg in the hive and every cell of uncapped brood dead and not more than one bee hatching to every square inch of brood, after thoroughly applying the remedy I introduced a queen just crawling from the cell. To-day I take pleasure in exhibiting this colony as one of the finest I own, lacking only a sufficient store of honey, and this without the addition to the original odorous hive and rotten combs of a single bee, cell, or brood, or anything whatever to assist, except the young queen.

"I extracted the honey from diseased colonies and treated the combs of such with the remedy as directed, and then exchanged hives and combs, giving the infested hives and combs to the healthy bees without cleansing or disinfecting a hive, and the diseased bees were given the hive and combs lately occupied by the healthy colonies. The contagion did not spread, and after two or three applications of the remedy all traces of it disappeared. I fed back the honey extracted from the diseased colonies for the bees to use in breeding, adding 2½ ounces of the remedy to each quart; and I also fed the mixture of bone-ash, rye flour, and honey as a substitute for pollen by pressing the paste into the cells on one side of a comb, and this I placed next to the brood in each hive. I would not advise any one to feed this bone-flour and rye-flour paste unless they wish to raise a great many bees. I also fed the salt, alkali, and acid mixture outside in the apiary, so that all the colonies could help themselves. No; I do not fear that any of the mixture will be stored for winter or get into the surplus apartment, as the bees seem determined to use all they can get of it in brood-rearing. All my hives are running over with bees ready for the fall honey harvest.

"As requested, I placed frames of sealed honey from diseased colonies in healthy

colonies, and the disease was not communicated; but the frames from which the honey had been extracted, such as contained pollen, uniformly carried with them the contagion, unless the combs were first thoroughly sprayed with the antidote, and colonies gathering no pollen, or but little pollen, recovered much sooner than those gathering pollen in considerable quantities—that is to say, the more pollen, the more treatment required.

"In reply to your question asking by what means and in what manner the disease was communicated to my apiary, I answer: I at first thought that it had originated spontaneously, but later and more careful inquiry leads me to believe that I introduced it into my apiary through my own carelessness. Both I and my neighbor (to whom reference was made in a former report) spent a day in some apiaries some distance from home in which the disease was raging. It would seem true that we brought the contagion home in our clothing. Other apiarists in our county who kept away from the contagion had no trouble. As to the progress of the disease in individual colonies, I would say that three or four weeks from the time the first cells of diseased brood are noticeable is sufficient to complete the ruin beyond redemption. I am surprised to hear that in some localities a colony may be affected for three or four months before ruin is complete. I have succeeded in raising some queens from one of these diseased colonies, treated with the remedy without removing the comb-frames, and I will give them every possible chance to reproduce and propagate the disease. I have no fears of a return of the disease where the treatment has been thorough."

2. Number of colonies in the apiary, 14. Every colony nearly ruined by the disease in most malignant form. This apiary is located on the same ground where 145 colonies perished last year from the same cause. The whole yard had been swept clean, everything had been burned up, and entirely new stock procured. Twelve colonies in this apiary were treated by copious and thorough applications of the remedy simply by setting the frames apart in the hive so that the spray could be directed over both sides. The frames containing brood were not removed from the hive, neither was the honey extracted. The treatment was applied every three or four days, and in three weeks the colonies were free from all appearance of disease. The other 2 colonies were treated with what is known as "the coffee cure," finely ground coffee being used as an antiseptic. The coffee failed to furnish any relief. Being dusted over and into the cells, it killed the little remaining unsealed brood. The salt, alkali, and acid remedy being applied, these 2 colonies also rallied, and "everything is all right now," was the last report.

3. Number of colonies, 100. Number apparently diseased, 48. A number of colonies had already been burned when the disease was reported. The remedy was thoroughly applied as directed, and in fifteen days the contagion had disappeared.

All the evidence so far obtained seems to prove that pollen is the medium through which the contagion is commonly introduced into the hive and by which it is communicated to both bees and brood.

The bacteria, "the disease germs," having been lately deposited on the pollen (from what source is not positively known, but probably from the decomposing bodies of other insects) before the organisms are washed from the blossoms by the rain or killed by the heat of the sun, as they lie exposed to his rays without any element essential to their culture and growth, are carried and stored with the pollen in the cell, or pass into the digestive system along with the live pollen taken by the bees for their own nourishment. By this means these agents of destruction are introduced into the organism of the bees, and through the same medium are they introduced into the cells of the uncapped larvæ. The bacteria, having found a lodgment in the organism of the bee, may or may not cause speedy death. If the bees are young and vigorous they may resist the ravages of the infection, yielding only after the organism is riddled with the bacteria, but if the bees are old and low in vitality the infection, if left to itself, brings speedy ruin. In the spring of the year I have dissected bees which had passed the winter in a colony in which this disease was present when the bees were put away in winter quarters the fall before. Their bodies had been completely honey-combed by the bacteria.

The fact that if a diseased colony is removed from the infested combs and hive and placed in an empty hive or in a hive with frames supplied with comb-foundation, even if the new hive be at once placed on the old location and the old hive and infested combs be burned and the bees at once liberated, the disease commonly disappears, seems also to furnish additional proof that the contagion is usually carried into the hive in the pollen, and, further, that the "disease germs" do not long retain their virility if exposed to the rain and rays of the sun; otherwise the bees would continue to carry in the infection. The bees being compelled to consume the contents of their honey-sacks in building new combs, none of the germs remain to be regurgitated in the new cells; but by this practice the bees are left to the tender

mercies of the bacteria, unless they be treated with an antidote. For obvious reasons the queens in such colonies should in any event be superseded as soon as possible. This method of treatment also contemplates the destruction or renovation of all hives and frames, the destruction of all broods, and the melting of all combs; a large percentage of the capital in honey-producing.

Another reason for believing that, except in rare cases, the disease is introduced by means of pollen is found in the fact that the larvæ rarely ever exhibit any symptoms of disease until about the time when the process of weaning begins, at which time the character of the food is changed from the glandular secretion, the pap, to the partially digested and undigested food. Live pollen is then added to the larval food, and with it the bacteria in greater or less numbers; growth is arrested; death ensues; putrification follows, and the soft pulp, of a grayish-brown color, settles to the lower side of the cell. As the mass dries up it becomes glutinous and stringy and reddish-brown in color and emits an offensive odor. Some of the larvæ will be partially capped, some completely capped, and some left uncapped, the condition in which the brood is left depending, I believe, upon the virulence with which the disease attacks both bees and brood. The remedies prescribed appear to destroy the bacteria and cure the bees of the contagion and restore them to natural vigor. The worker bees then cleanse the hive of dead bees and brood and clean out and renovate the cells, and the colony resumes its normal condition.

That the contagion may sometimes be borne from hive to hive by the wind appears to be true, as it was observed in one of the apiaries which I treated for this disease during the past summer that of a large number of diseased colonies in the apiary, with the exception of two colonies, all were located to the northeast of the colony in which the disease first appeared. The prevailing wind had been from the southwest.

That the disease germs may be carried upon the clothing and hands appears probable, from the fact that in one neighborhood the disease appeared in only two apiaries, the owners of which had spent some time working among diseased colonies at some distance from home, while other apiarists in that locality who had kept away from the contagion had no trouble from foul-brood.

THE CONTROL OF REPRODUCTION.

The improvement which has been made in mechanical devices and methods of management by the scientific and practical apiarists of the United States during the past twenty-five years has resulted in establishing the claims of the industry of bee-keeping to a place among the various branches of rural husbandry which are the acknowledged sources of the nation's wealth. Improvements in the art of bee-keeping and in the devices by which the art is practiced are continually being made, and the degree of advancement made in the past is an earnest of the progress awaiting development in the future.

Improvements in devices and methods of management and importing races of bees reported to possess desirable qualities and characteristics have chiefly absorbed the attention of American bee-keepers. It is not strange that reliance has been placed upon these resources as the means by which the best results were to be realized, rather than upon a persistent and skillful application of the laws of heredity and descent and dependence upon the influence of intelligent selection and skillful crossing as a means for developing the highest attainable standard of excellence in *the bee*, the chief factor in permanent advancement.

The difficulties attending the control of the process of reproduction, of applying the laws of heredity and descent, and securing the influence of persistent, intelligent selection in breeding bees have appeared to be almost insurmountable. The very persistent efforts which have been made to improve the bees of the United States by yearly importations of the best races in their purity has also been attended with serious drawbacks and hindrances. These bees, bred for countless generations in a foreign habitat and under climatic conditions widely different from ours, are here submitted to conditions of domestication for which they are ill adapted. Any modification and adaptation of habits, instinct, and physiological structure which may have been secured by breeding a few succeeding generations under the altered conditions and requirements incident to domestication in the United States have been lost with each fresh importation of ancestral stock, and the work of securing the variability and adaptability of instinct, habit, physiological structure, and functional capacity essential to domestication here must be begun *ab initio*.

That some practical method might be discovered by which the process of reproduction could be controlled has long been the hope of all progressive apiculturists. With the control of fecundation assured, progress in scientific apiculture would be rapid and permanent.

In obedience to your instructions I have continued my experiments in striving to discover a practical method by which the fecundation of queen bees may be controlled. This I have endeavored to accomplish by two different methods, in both of which I have been in a degree successful. During the past summer, however, a drought set in in May, almost with the beginning of the breeding season, which was said to be the severest and most protracted known in this locality for twenty-five years. No rain fell during eleven weeks, and during the four weeks next succeeding the eleven weeks without rain we had but three light showers, scarcely sufficient to lay the dust, practically resulting in an unbroken, all-consuming drought fifteen weeks in duration. Under such conditions I found it impossible to bring many of my experimental tests to a successful issue.

Having discovered last year that it was possible to introduce the drone sperm into the spermatheca of the queen bee during the term of orgasm by artificial means, and that fecundation was practicable by such means, I attempted to perfect a method by which this could be done with ease and certainty. For the purpose of holding the queen bee in position for introducing the drone sperm I made what I call a queen-clamp, which consists of a block of wood 2 inches square and 4 inches long, in one end of which is an opening in size and shape like the upper two-thirds of a queen-cell, with the small end up. This block is sawed in two in the middle, leaving half the cell-shaped opening on either half. Grasping the queen by the wings or thorax I place her in one half of the cell-shaped opening and carefully close the other half over her. I then place a rubber band around the block and stand it on end. This leaves the queen in position, head downward, the lower half of her abdomen protruding, and confined in such a manner that she cannot receive any injury. For the purpose of appropriating and depositing the male sperm I used a hypodermic syringe. I removed the sharp injecting needle, and in its place substituted a nozzle having an opening of sufficient size to admit a knitting-needle of medium size. Over this nozzle I slipped a small, smooth tube, drawn to a point so small that the opening in the small end is not more than half as large as that in the nozzle. After selecting the drone I wish to use, I grasp the head and thorax between the thumb and finger, and by a continued pressure cause him to perform the expulsion act. I then remove the bean in which the spermatozoa are massed and squeeze the contents into a very small glass receiver, an eighth of an inch in depth and in diameter. I then add a drop of glycerine diluted with warm rain water, and take up the spermatozoa with the syringe, using the wide nozzle. I then slip the cap having a fine smooth point over the nozzle and inject the spermatozoa into the vulva of the queen. The queen, which has been held in position by the clamp while the preparations were being made, naturally bends the abdomen downward whenever so confined. The vulva is easily opened to admit the point of the fine nozzle-cap when the abdomen is lifted up straight. Of twenty-seven queens treated by this method the last week in May and the first week in June six proved to be successfully fertilized. After that time, although I was persistent in my efforts to succeed and made many and repeated trials, I met with success only occasionally.

Another method by which I succeeded in fertilizing a few queens in May, before the bees began killing the drones, was in the manner described in my report of last year. I took a number of young queens from nursery cages, clipped their wings, and introduced them to queenless nuclei. When they were seven days old, orgasm being well progressed, I placed them each in turn in a queen-clamp, and, holding them back downwards, I picked drones from a comb taken from a populous hive, and caused them to expel the generative organs, and selecting those in which the contents appeared of the color and consistency of albumen, I placed drops of the seminal fluid upon and in the vulva of the queen, which were eagerly received. After the introduction of the drone sperm these queens were treated by the bees as fertile queens, and in one or two days assumed the appearance of fertile laying queens, and in from three to six days began to lay fecundated eggs.

The fact that I did occasionally succeed in fecundating queen bees by these methods, which proved upon trial as prolific as any queens I had which had been naturally fertilized, queens which I had hatched in an incubator and in nursery cages, whose wings I had mercilessly clipped as soon as they had crawled from the cell, and which I knew had never been upon the wing, seemed to furnish reason to hope that I would be able to discover a method which would be uniformly successful. The hope of reaching this much-desired result made me persist in the face of discouragements incident to experimental work in breeding bees during the prevalence of a protracted drought. I am by no means discouraged by the partial success now realized. On the contrary, I am hopeful that under more favorable conditions better results may be obtained, and until other and untried resources fail I should not feel warranted in abandoning effort.

Observation and experiment lead me to believe that drone bees differ in degrees

of procreativeness, and that the development and exercise of the procreative faculty are under the control of the worker bees.

First, there appeared to be drones of the impotent sort. If such be taken between the thumb and finger, no pressure short of crushing is sufficient to expel the sex organ. When forced to position external to the body, or if removed by a dissection, the organs are found to be nearly or quite empty, the few spermatozoa being massed in a hard lump, and but little mucus being present, and that little watery and clear and having no consistency.

Another sort of drones are those in which the mucus surrounding the spermatozoa is thick and curdy. With this sort I have not been able to fertilize a queen. The procreative principle is present in quantity, but the element in which it may be liberated and floated into the organs of the queen appears to be wanting.

A third sort of drones are those in which the sex organs are completely filled with spermatozoa and an abundant supply of albuminous fluid. It is only with this latter sort that I have been able to succeed in fecundating queens.

The facts observed seem to warrant the belief that it is the prerogative of the worker bees to determine the degree of development and dominate the function of the drones as they do the succeeding generations of workers and queens, the superior intelligence of the workers ordering the entire economy of the hive. During the first half of the severe and protracted drought of the past season I was able to rear a few drones by resorting to the usual methods employed for stimulating drone-rearing, but one-third of the entire number proved upon trial to be of the sort which I believe to be impotent, and nearly all of the remaining two-thirds were of the second class, not more than 5 or 10 per cent. of the entire number being furnished with the albuminous liquid necessary to enable the drone to voluntarily perform the expulsion act and complete the function of copulation, the filling of the spermatheca of the queen; for I am led to believe that the presence of this fluid, more than any odor or other influence from the presence of the queen during orgasm, excites in the naturally frigid drones the sexual desire and assists in the execution of the expulsion act and furnishes the element in which the spermatozoa are floated into the spermatheca, and also that the workers intelligently and purposely determine the sexual development and dominate the fitness, the desire, and capacity of the drone, as they do the physical development, the fitness, the desire, and capacity of worker and queen bees for the natural performance of their individual functions; that is to say, if drones are reared during a drought by artificially approximating the conditions under which the desire for drone-rearing normally arises, only a small percentage of the number will be sufficiently furnished with the food essential to complete sexual development, the counterpart of which is seen in a less degree in the rearing of worker larvæ; and, further, if there is a failure of honey or if for any reason the swarming impulse is absent and no emergency exists for the forming of a new colony, very few of the sexually mature drones are supplied with the food-elements essential in producing the secretion which excites sexual desire and supplies the agency by which the spermatozoa are freed and floated into the spermatheca, the counterpart of which is seen in the refusal of the worker bees to copiously supply the queen with the rich glandular secretion essential to oviproduction whenever their instinct warns them that ovipositing should cease and that further brood-rearing would only be a waste of energy, resulting in a generation of consumers and non-producers; for the queen is only a mother, and in no sense a majesty; only a machine, not a monarch. Other facts in my experience might be mentioned in support of this belief.

October 15, Mr. Otis N. Baldwin, of Clarksville, Mo., wrote me that he had met with success in practicing the method of fertilization described in my report of last year and that he had discovered that drones were of three kinds, namely: "Dwarfed, immature, and ripe." As directed by your letter of instructions of November 5, I went to Clarksville and interrogated Mr. Baldwin concerning his experience and observations, and I herewith give the substance of his statement made in reply to my questions. He said, "I first go to my nursery and take the queens and cage them. I then go to my hive of drones and pick out as many as I think I may need, and then proceed in the manner you describe in your report of 1885. I believe the whole secret of success lies in the drones, and I am not able to tell how old the drone must be, or how the right condition is brought about, or whether it was originally intended that only a very small percentage of drones should be capable of fertilizing a queen. I have, however, discovered that there are three kinds of drones. First, the drone which when squeezed bursts with apparently dry organs of generation. Second, drones which burst with an abundance of seminal fluid resembling a mixture made by adding bromides to a silver solution. Third, drones which bursting show a fluid resembling albumen. With the two former kinds I have succeeded in fertilizing a single queen. With the latter I have fertilized over two hundred queens the past

season with but few failures after I found out the difference in drones. I carefully grasp the thorax of the queen between the thumb and finger of the left hand and with the right I pick up the drone which I have selected and press the thorax and abdomen of the drone until the generative organs are expelled, using as many as I need until I find one in which the color and consistency of the fluid suits me. Sometimes only a few of the right kind can be found in as many as one hundred. I place a few drops of the male fluid upon the vulva of the queen, which is eagerly received, using one, and only one, drone for each queen. I have fertilized queens by this method that were not a day old, and others more than fifteen days old, and after clipping their wings introduced them to their colonies, and they began laying in from six to eight days and were satisfactorily prolific. As nearly as I could tell, those fertilized early were more prolific than those treated after they were ten days old, but the right condition of the drone is very essential. It is very difficult to get drones ripe enough before the first half of May and after the first half of August, but during June and July this method may be operated with gratifying results. Queens fertilized by this method and directly introduced into a queenless colony are rarely ever molested by the bees. I clipped the wings of the first twenty or twenty-five queens I succeeded in fertilizing by this method, and finding the method worked to my satisfaction and with but few failures, I clipped no more wings."

The experience here detailed, as far as it relates to the procreativeness of drones, is in agreement with the facts within my own observation already set forth. The claim that a very large number of queens were successfully fertilized as set forth, and that, too, with but few failures in the whole number attempted, is lacking in the element of absolute certainty and completeness of detail which would entitle it to acceptance as of any scientific value. Mr. Baldwin assured me that "there could have been no mistake about it;" but in order to effectually guard against all possibility of the test being abortive, all the queens claimed to have been artificially fecundated should have had their wings thoroughly clipped before they were liberated. But the fact that the repeated successes were realized when the young queens were clipped upon being taken from the nursery cage, never having had opportunity to bear their weight upon their wings, is an encouraging step in advance towards the solution of the most difficult problem in practical bee-keeping. Another season, with the presence of favorable conditions, will determine the practicability and value of this method.

FERTILIZATION IN CONFINEMENT.

Realizing that natural methods nearly always possess advantages over artificial methods, I determined if possible to gain control of reproduction by the fertilization of queens in confinement. That some inexpensive and practicable method might be devised by which the natural mating of queens in confinement could be secured has very long been hoped for by all progressive apiarists. Very many attempts, in a variety of ways, some of which involved the outlay of considerable sums of money, have been made, but difficulties apparently insurmountable have been encountered.

I removed the queens from 6 colonies which I had had confined in the house for experimenting with bees and fruit, a house 10 feet by 16 feet, 8 feet high, partly covered on the sides with wire-cloth, a wire-covered sash in the gable, and large screen wire-covered doors in each end. These were strong colonies, which had been confined in this house for thirty days and had learned the location of their hives, and from these the bees flew daily in great numbers, returning frequently to their hives. Into these 6 colonies I introduced virgin queens hatched from cells which I had placed in wire cages. Into each colony the virgin queen was placed without being removed from the cage in which she was hatched. In due time they were accepted and liberated. The day these queens were five days old I liberated about ten drones near to the entrance of each of these hives. These drones were brought from hives in the apiary, and upon being liberated most of them persisted in flying against the wire-covered sides and windows in the gable, and few ever entered the hives. Here again there was frigidity or disability apparent among the drones. When the young queens flew from the hive seeking a mate they mingled among the drones, crawling over them and caressing them with their antennæ, meeting with no response. These queens, with one exception, seemed to have no difficulty in getting the location of their respective hives. The result of this trial was, one queen of the six was fertilized, and after she had laid eggs with regularity in two-thirds of the cells on both sides of one frame, after clipping the queen's wings, I removed this frame, with the queen and adhering bees, to a nucleus in the yard, and from the eggs laid in confinement worker bees hatched in due time, and the queen continued to lay as long as the nucleus was fed, there being nothing in the fields for the bees to gather. All the eggs laid by this queen were

fecundated eggs. Being convinced that as far as the queens were concerned the difficulties in the way of success were not insurmountable, and that the main trouble was that the drones had not been furnished by the workers with the glandular secretion or the food suitable for producing the albumenlike secretion which I had been led to believe essential to produce sexual desire and to assist in the performance of the copulative act, from these same colonies I removed the remaining unmated queens, and to each I introduced another virgin queen as before.

I then went to a distant apiary, and secured an unusually strong colony which was under the swarming impulse. A few queen cells were being built and a moderate supply of drones was present. This was late in the season. This colony had not cast a swarm during the year, and was the only one I could find, after considerable search and inquiry far and near, having any drones, and probably owing to the excessive drought only an occasional one of the number examined had been prepared by the workers for the procreative function. I took this colony home and placed it in the wire-covered house at the end opposite that in which the virgin queens were located. I clipped the wings of the old queen so that she could not leave the hive, and upon being liberated the workers and drones of this hive made less effort to escape than those brought in from the apiary near by, and some seemed reconciled to their new surroundings. The workers soon learned their location and drones were soon to be found in nearly every hive in the house. The result of this trial was that three of the six queens were fertilized, and as soon as they had each laid five or six hundred eggs I clipped their wings and removed them, together with their colonies, to the yard and fed them, and all the eggs laid by these queens produced worker bees. I am much encouraged by the success so far realized under conditions so unfavorable.

With the return of spring I hope to follow out your suggestions and continue the test, using a large wire-covered inclosure for the purpose; with hives so arranged on the sides that the worker bees may have unobstructed flight, while the drones and queens, being restrained by means of queen-excluding zinc placed before the outside entrance to the hive, may fly and mate within the inclosure and readily return to the hives from whence they came. If practical control of reproduction can be secured by so simple and inexpensive a method—and the facts from my experience as given above seem to warrant the conclusion that this is true—then the Rubicon of scientific apiculture is passed.

EXPLANATION TO PLATES TO REPORT OF ENTOMOLOGIST.

Where figures are enlarged the natural sizes are indicated in hair-lines at side, unless already indicated in some other way on the plate.

EXPLANATION TO PLATE I.

THE COTTONY CUSHION-SCALE.

(Original.)

FIG. 1.—*a*, adult male—enlarged; *b*, hind tarsus of same; *c*, wing and poiser of same, showing hooks and pocket—still more enlarged.

FIG. 2.—*a*, newly hatched larva from below—enlarged; *b*, antenna of same; *c*, tarsus—still more enlarged.

FIG. 3.—Adult female, side view, showing the pale, greenish-gray form and with part of egg covering torn away, showing the carmine eggs and egg-stain—enlarged.

FIG. 4.—Adult female, dorsal view, showing reddish-brown form—enlarged.

FIG. 5.—Male cocoon—enlarged.

FIG. 6.—Branch of orange tree with mass of insects *in situ* and as they appear soon after death—natural size.

EXPLANATION TO PLATE II.

THE COTTONY CUSHION-SCALE.

(Original.)

FIG. 1.—Outline of the egg—greatly enlarged.

FIG. 2.—Dorsal view of newly-hatched larva—greatly enlarged.

FIG. 3.—*a*, female larva, second stage, ventral view—greatly enlarged; *b*, antenna of same—still more enlarged.

FIG. 4.—Female larva, third stage, ventral view—greatly enlarged.

FIG. 5.—Adult female (fourth stage), dorsal view—greatly enlarged; *a*, antenna—still more enlarged.

FIG. 6.—Greatly magnified portion of lateral border of adult, showing bases of glassy filaments.

FIG. 7.—Male larva, second stage, ventral view—greatly enlarged.

FIG. 8.—Male pupa, ventral view—greatly enlarged.

EXPLANATION TO PLATE III.

ENEMIES OF THE COTTONY CUSHION-SCALE.

(Original.)

FIG. 1.—*Isodromus iceryæ*—greatly enlarged.

FIG. 2.—*Blapstinus brevicollis*—enlarged.

FIG. 3.—*Blastobasis iceryœella*—enlarged.

FIG. 4.—*Largus succinctus*—enlarged.

FIG. 5.—*Corizus hyalinus*—enlarged.

FIG. 6.—*Forficula* found preying on *Icerya*—enlarged.

EXPLANATION TO PLATE IV.

(Photo-engraved from a photograph.)

A lemon orchard at Los Angeles, infested by Cottony Cushion-scale.

EXPLANATION TO PLATE V.

(Photo-engraved from a photograph.)

Spraying outfit used in California in operation against the Cottony Cushion-scale.

EXPLANATION TO PLATE VI.

THE SOUTHERN BUFFALO-GNAT.

(Original.)

FIG. 1.—*Simulium pecuarum:* Larva—enlarged.
FIG. 2.—*a*, ventral view of head of larva; *b*, lateral; *c*, dorsal view of same—all greatly enlarged.
FIG. 3.—*a*, mentum of larva; *b*, labium, *c*, labrum of same—all greatly enlarged.
FIG. 4.—Pro-leg of larva—greatly enlarged.
FIG. 5.—*a*, antenna of larva; *b*, mandible of same—greatly enlarged; *c*, tip of mandible—still more enlarged.
FIG. 6.—Maxilla of larva—greatly enlarged.
FIG. 7.—Tip of abdomen of same, showing breathing organs—greatly enlarged.
FIG. 8.—Pupa—enlarged; *a*, *b*, *c*, spines of dorsal and ventral surface of abdomen of same—still more enlarged.

EXPLANATION TO PLATE VII.

THE SOUTHERN BUFFALO-GNAT AND THE TURKEY-GNAT.

(Original.)

FIG. 1.—*Simulium pecuarum:* Fan of larva—greatly enlarged.
FIG. 2.—*Simulium meridionale:* Larva—enlarged.
FIG. 3.—Same: *a*, antenna; *b*, mandible—greatly enlarged; *c*, tip of mandible—still more enlarged.
FIG. 4.—Same: Mentum—greatly enlarged.
FIG. 5.—Same: Breathing organs — greatly enlarged.
FIG. 6.—Same: *a*, empty pupa-case; *b*, case with pupa projecting from it—enlarged.

EXPLANATION TO PLATE VIII.

BUFFALO-GNATS.

FIG. 1.—*Simulium pecuarum:* Head of adult male—greatly enlarged. (Original.)
FIG. 2.—Same: Head of adult female—greatly enlarged. (Original.)
FIG. 3.—Same: Adult female from side—enlarged. (Original.)
FIG. 4.—*Simulium meridionale:* Adult male from side—enlarged. (Original.)
FIG. 5.—*S. pecuarum:* Dorsal view of adult female—enlarged. (Original.)
FIG. 6.—*S. meridionale:* Dorsal view of adult female—enlarged. (Original.)
FIG. 7.—*Simulium* sp.: *a*, portion of egg-mass from side; *b*, same, from top; *c*, *d*, individual eggs—enlarged. (After Barnard.)

EXPLANATION TO PLATE IX.

FIG. 1.—Larva of *Chironomus* sp.: *a*, dorsal view with pediform appendages retracted and jaws closed; *b*, lateral view with same parts extended; *c*, egg-mass—all enlarged; *d*, maxillary palpus; *e*, labial palpus; *f*, labium; *g*, mandible—still more enlarged. (After Riley.)
FIG. 2.—*Chironomus plumosus:* *a*, adult, dorsal view; *b*, pupa, ventral view—enlarged. (Original.)
FIG. 3.—*Hydropsyche* sp.: *a*, dorsal view of larva—enlarged; *b*, side view of anal hook of same—still more enlarged. (Original.)
FIG. 4.—Same: Side view of head and first thoracic segment of larva — enlarged. (Original.)
FIG. 5.—Same: Web of larva — enlarged. (Redrawn from Clarke.)

EXPLANATION TO PLATE X.

THE FALL WEB-WORM.

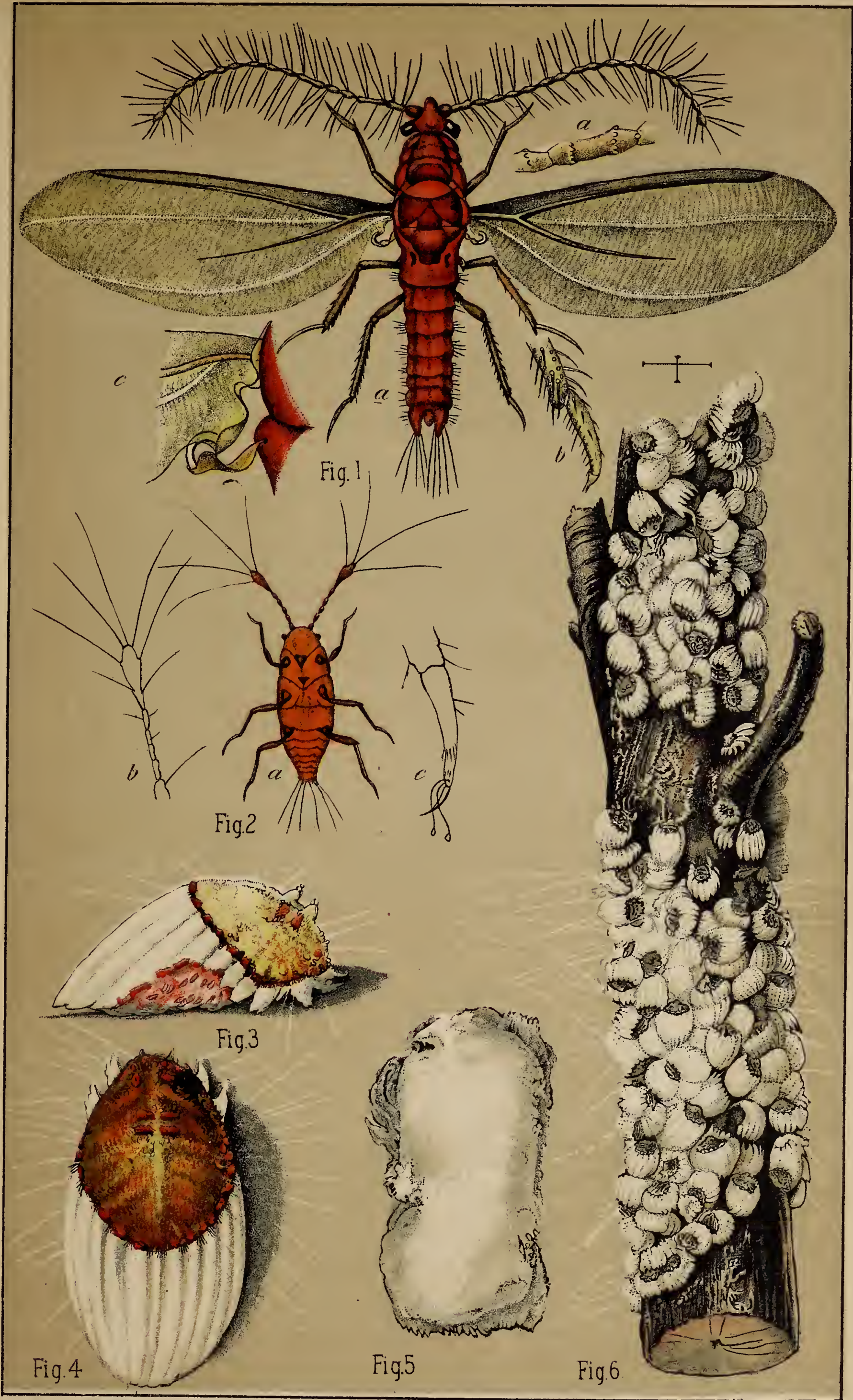
(Original.)

FIG. 1.—*a*, dark larva from side; *b*, light larva from above; *c*, dark larva from above; *d*, pupa, ventral view; *e*, pupa from side; *f*, adult—all slightly enlarged.
FIG. 2.—*a–j*, wings of a series of adults, showing graduation from pure white form (*cunea*) to one profusely spotted with black and brown (*punctatissima*)—natural size.
FIG. 3.—*a*, moth ovipositing upon leaf—natural size; *b*, a few eggs *in situ*—enlarged.
FIG. 4.—*Meteorus hyphantriæ:* *a*, adult; *b*, cocoon—enlarged.

EXPLANATION TO PLATE XI.

(Photo-engraved from a photograph.)

View of a Washington street in late September, 1886, showing complete defoliation of the Poplars on the west side and almost complete exemption of the Maples on the east side.

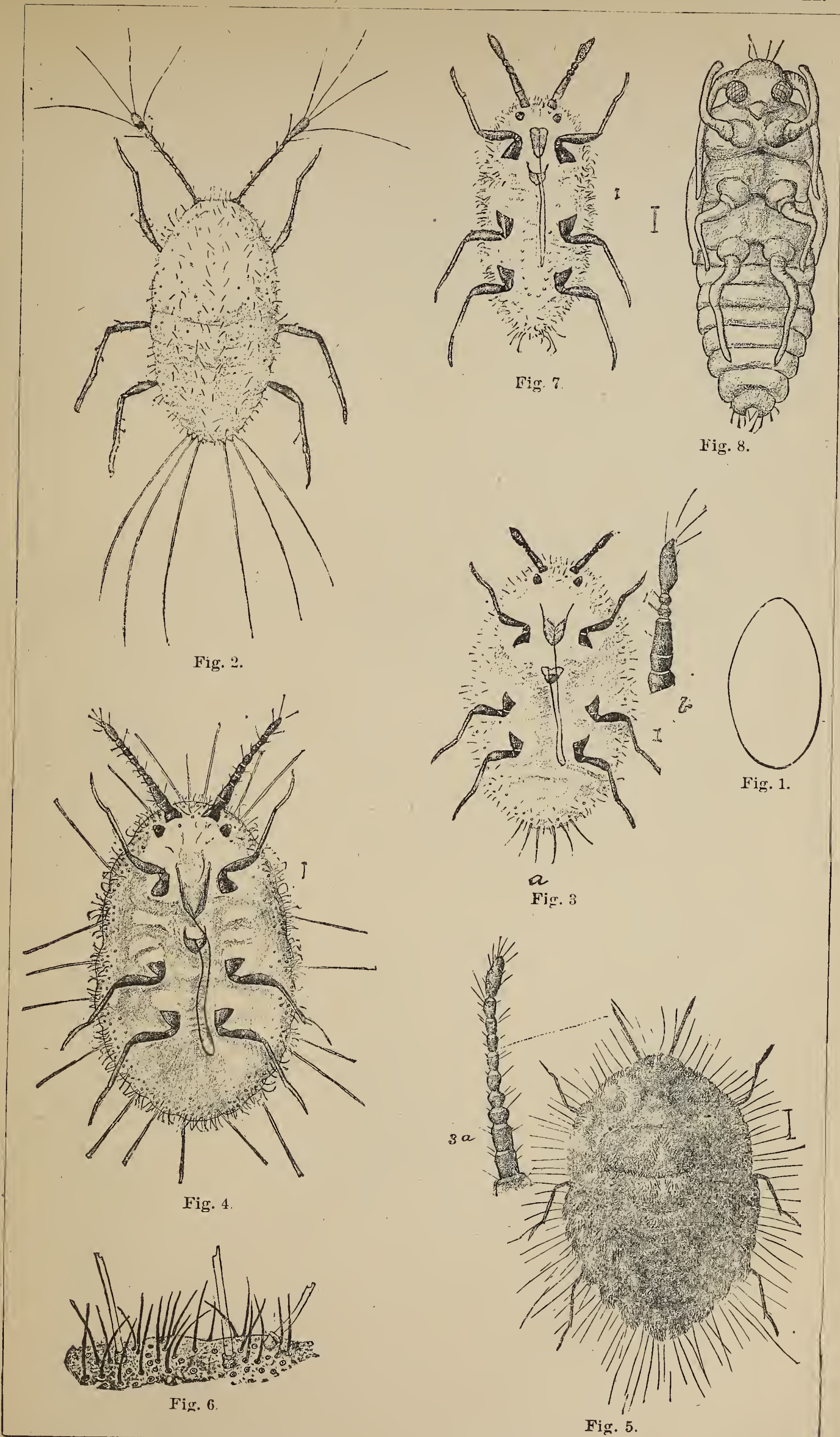


C.V. RILEY; L. SULLIVAN, PINX.

GILES LITHO. & LIBERTY PRINTING CO. N.Y.

THE ORANGE ICERYA, OR COTTONY-CUSHION SCALE.

(Icerya purchasi–Maskell.)



THE COTTONY CUSHION-SCALE.

Fig. 1.

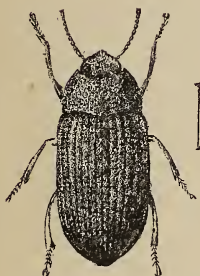


Fig. 2.

Fig. 3.

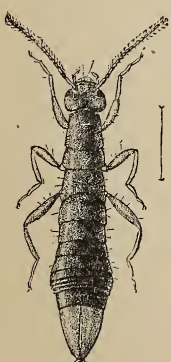


Fig. 6.

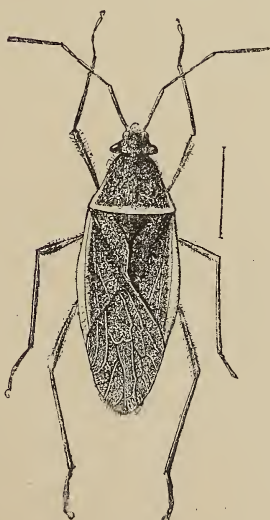


Fig. 4.

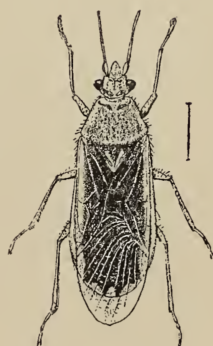
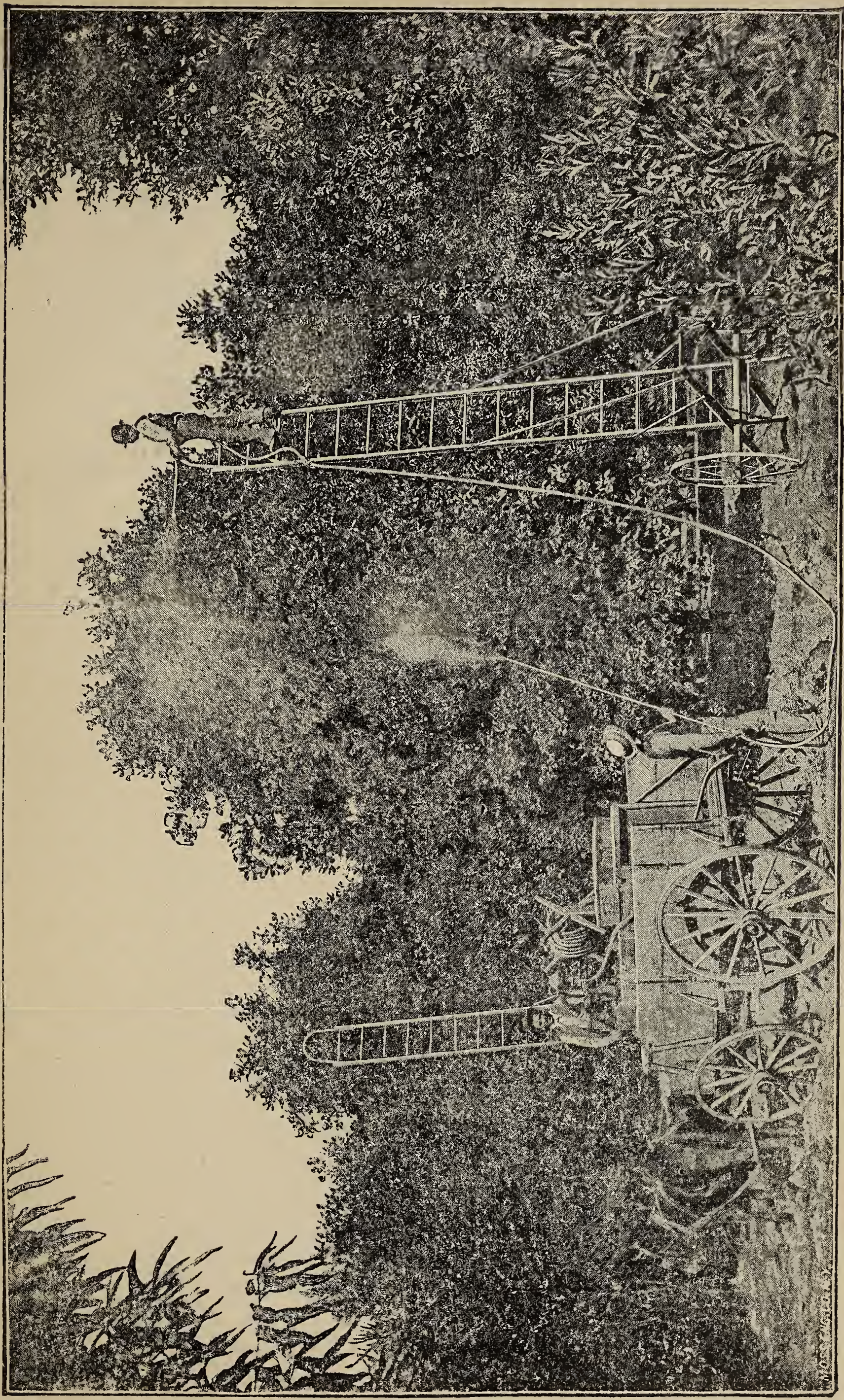


Fig. 5.

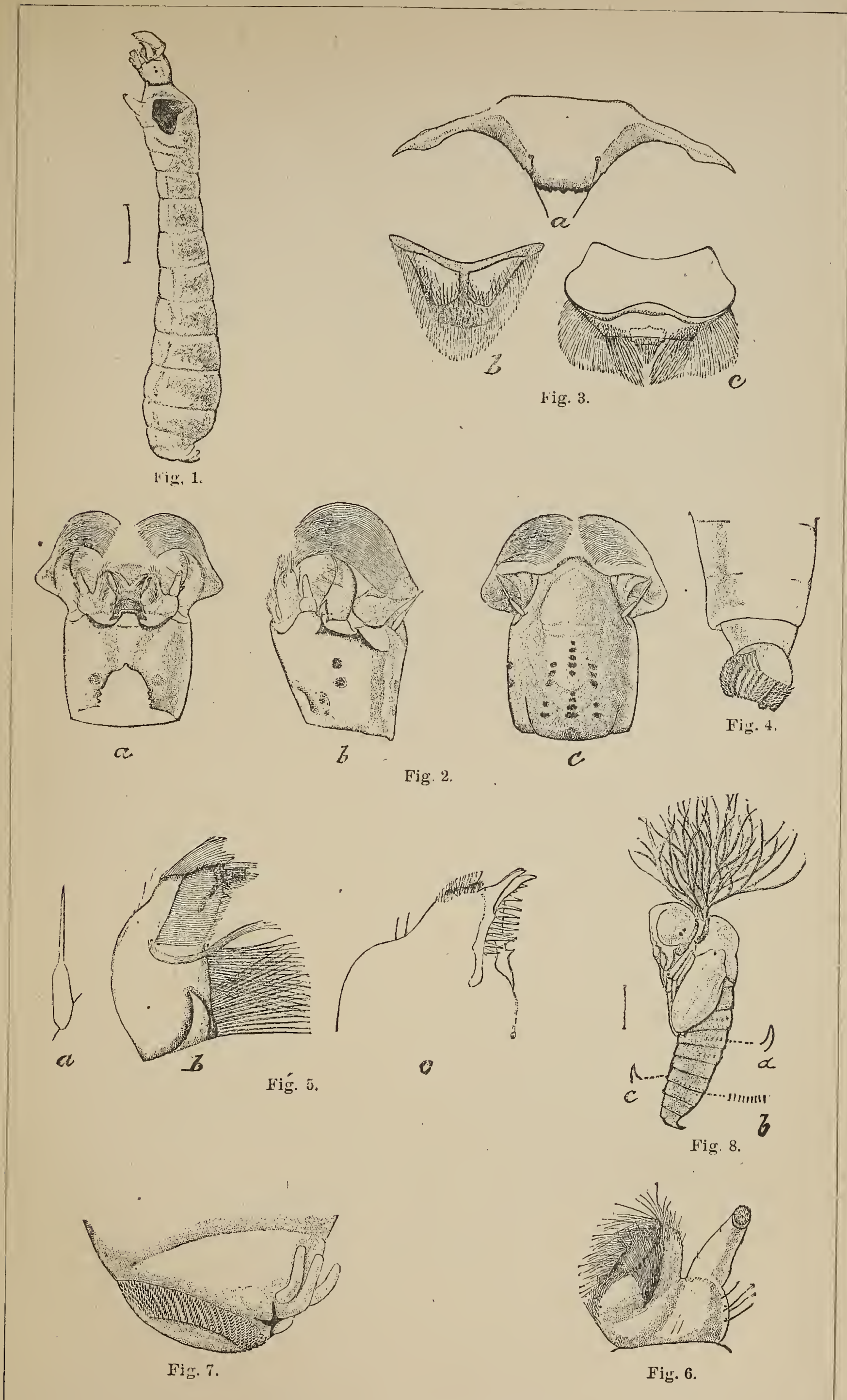
ENEMIES OF THE COTTONY CUSHION-SCALE.

PLATE IV.

LEMON ORCHARD INFESTED BY COTTONY CUSHION-SCALE.



SPRAYING OUTFIT IN OPERATION AGAINST COTTONY CUSHION-SCALE.



The Southern Buffalo Gnat.

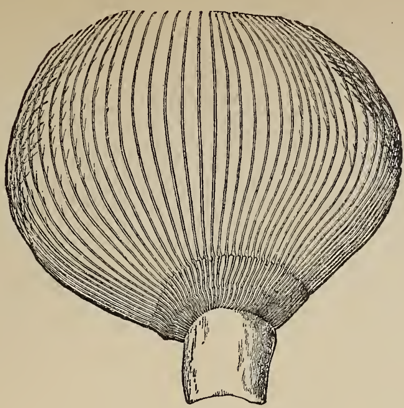


Fig. 1.

Fig. 2.

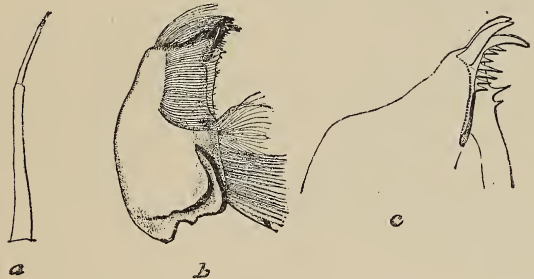


Fig. 3.

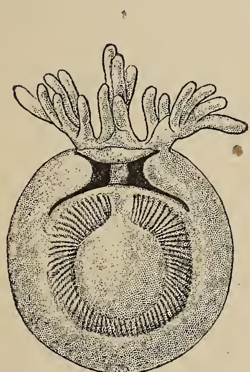


Fig. 5.

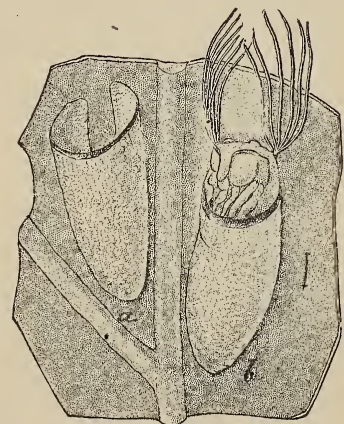
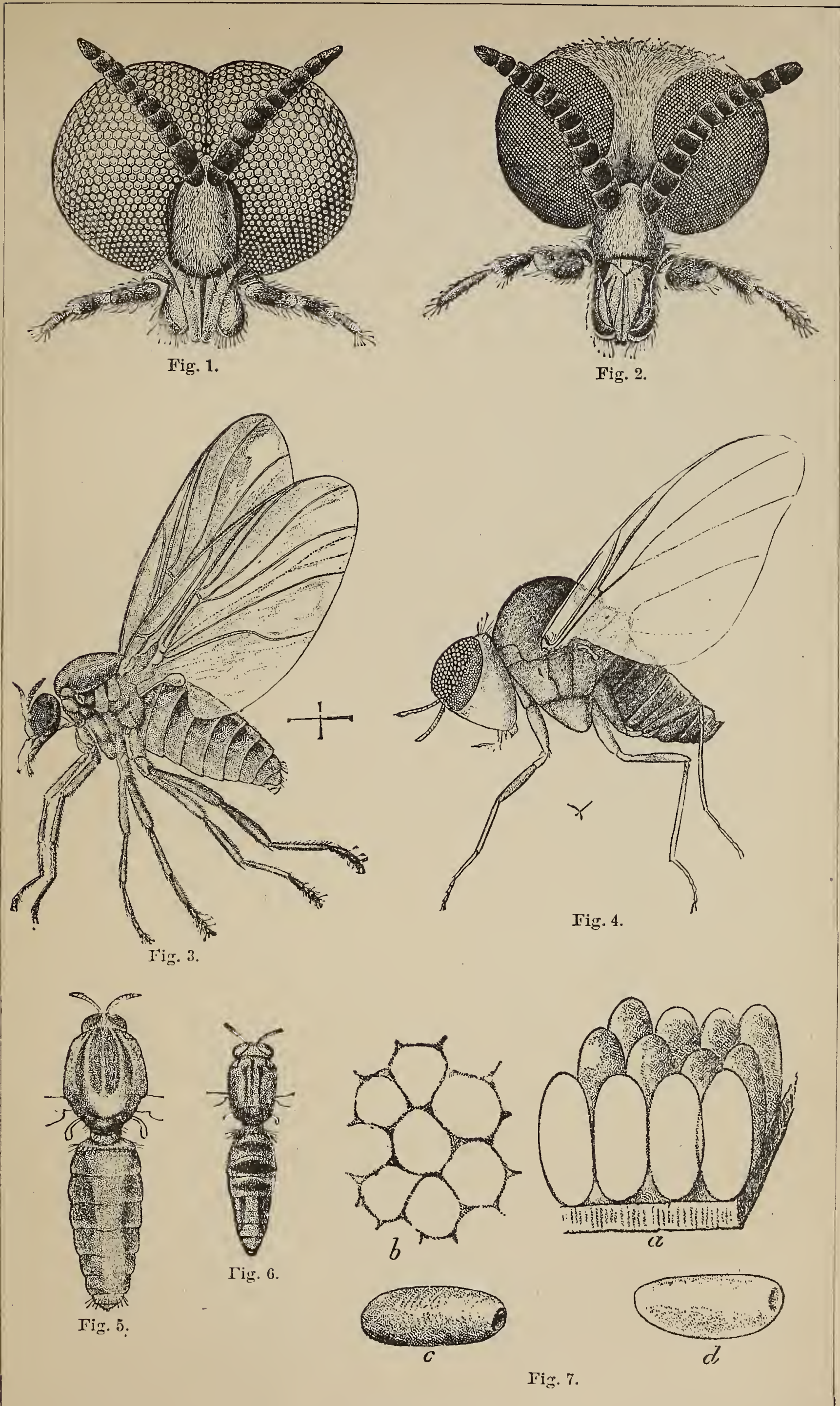


Fig. 6.

Fig. 4.

THE SOUTHERN BUFFALO GNAT AND THE TURKEY GNAT.



THE SOUTHERN BUFFALO GNAT AND THE TURKEY GNAT.

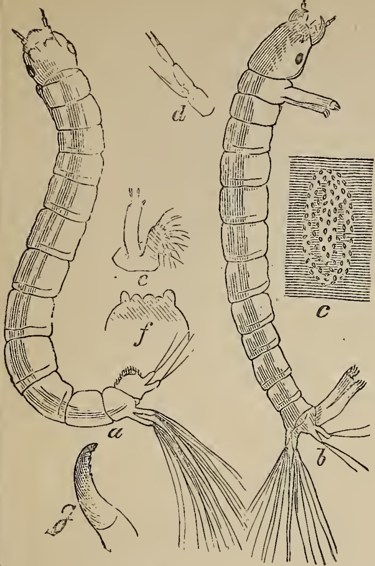


Fig 1.

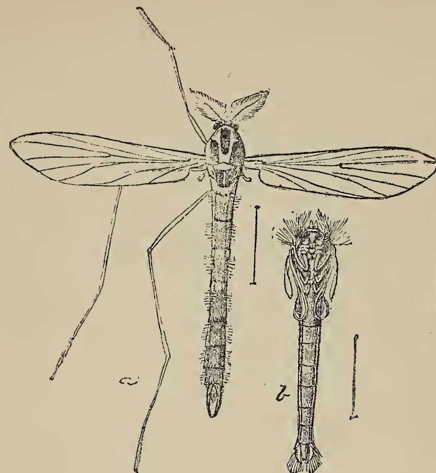


Fig. 2.

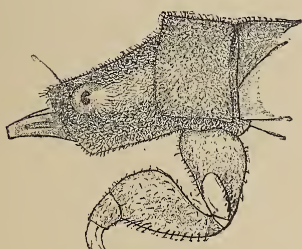


Fig. 4.

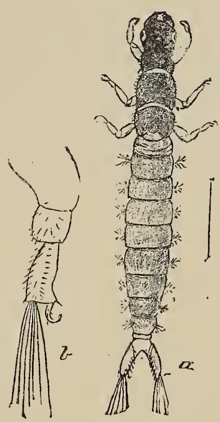


Fig. 3.

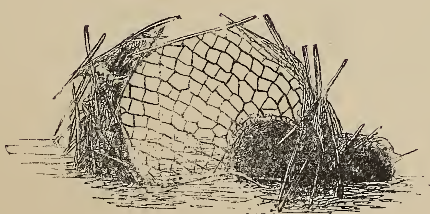


Fig. 5.

PLATE X.

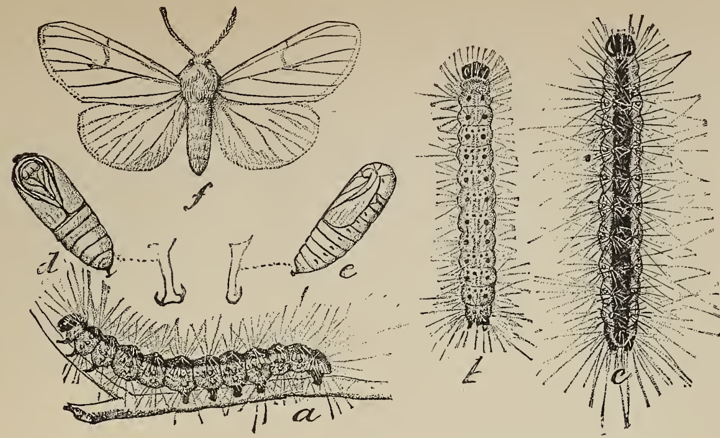


Fig. 1.

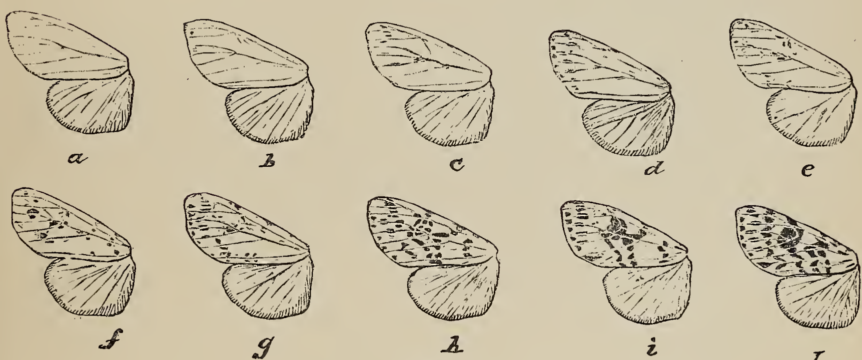


Fig. 2.

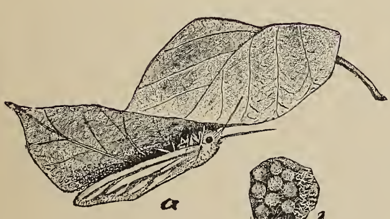


Fig. 3.

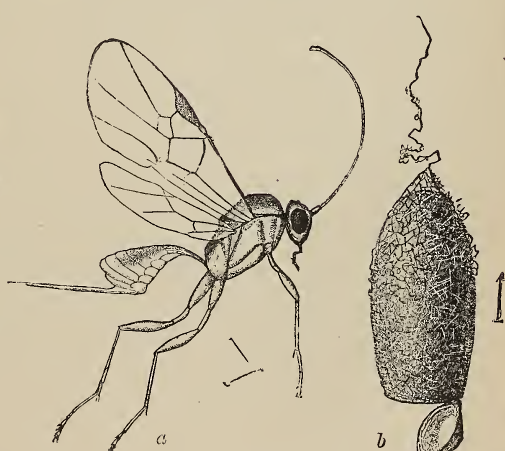
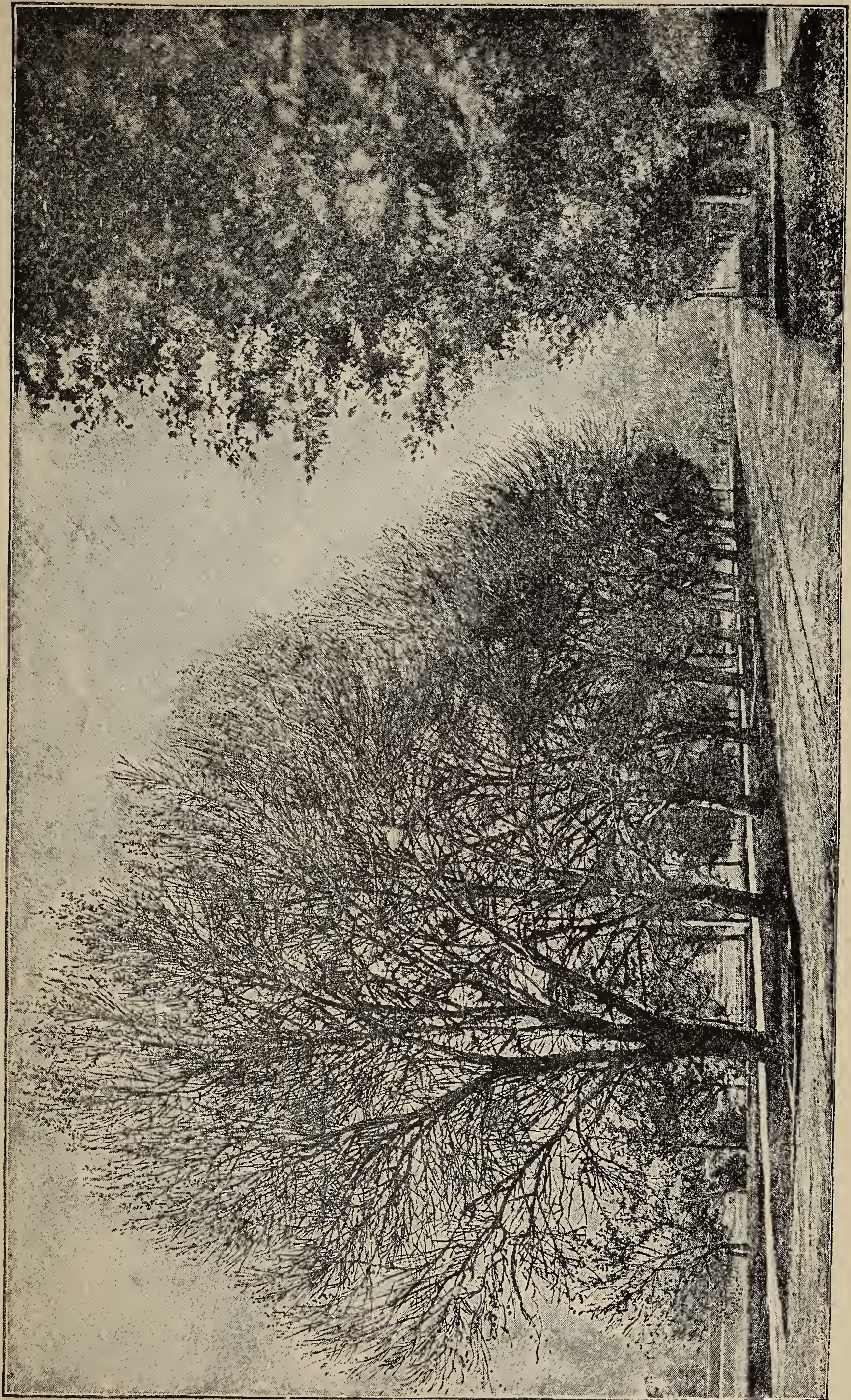


Fig. 4.

THE FALL WEB-WORM.



RAVAGES OF THE WEB-WORM ON POPLARS ON ONE SIDE OF A WASHINGTON STREET AND EXEMPTION OF MAPLES ON THE OTHER.

GENERAL INDEX.

PLANT INDEX.

H. A. Gossard

AUTHOR'S EDITION.

FROM THE ANNUAL REPORT OF THE DEPARTMENT OF AGRICULTURE FOR THE YEAR 1887.

REPORT

OF

THE ENTOMOLOGIST,

CHARLES V. RILEY, M. A., PH. D.,

FOR

THE YEAR 1887.

[CONTAINING REPORTS FROM ASSISTANTS AND AGENTS OF THE DIVISION.]

(WITH ILLUSTRATIONS.)

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1888.

TABLE OF CONTENTS.

REPORTS OF AGENTS—Continued.

REPORT OF THE ENTOMOLOGIST.

INTRODUCTION.

SIR: I have the honor to present herewith my annual report for the year 1887. Much is omitted therefrom, both on account of restrictions as to the size of the volume and the increased number of the divisions of the Department which must be represented in the general report, and on account of the policy which I am more and more adopting, with your sanction, of confining the publication of articles of less general interest, or rather those upon insects affecting the more restricted crops or industries, to the special bulletins of the Division. The chief articles in this report, therefore, treat of two insects which are found throughout the country and which affect seriously several of our most important crops.

The entomological event of the year has been the great damage done by the Chinch Bug in most of our grain-growing States of the West. Mr. Dodge, the Statistician, reports that at the very lowest estimate the loss for the year has amounted to $60,000,000 in nine States. Owing to the fact that Bulletin 5 of the U. S. Entomological Commission treated of the species with some detail, and to the further fact that I have dealt with it fully in my earlier writings, especially while State Entomologist of Missouri, no complete account of it has been published by the Department. There is so much that is new to investigate and work at that I find it difficult to dwell at length on insects to which I have given so much time in the past. The bulletin just mentioned is, however, out of print, and the demand for information on the subject is so constant that I have had Mr. Howard prepare as the first article of this report a complete account of the species. The article not only digests all that has been published, but includes a number of unpublished facts, mostly derived from the observations of the field agents of the division. The only new remedy of importance brought into use since the publication of the Missouri reports, viz, the kerosene emulsion, is here treated in some detail.

Much the same reasons may be given for the publication of the second article of the report, which has also been prepared by Mr. Howard. The Codling Moth is the most injurious of our orchard pests, and a complete summary of its habits and remedies is needed. Recent experiments have shown the value of arsenical spraying, if done carefully and at the right time, and more space is therefore devoted to the consideration of this remedy than to the others.

An account of the investigation of the Hop Aphis, mentioned in the Introduction to my last report, is deferred for a few months. The investigations made have been thorough and satisfactory, and justify, in a striking manner, the position taken a year ago. The

hibernation upon Plum in the egg state, the migration therefrom in spring to Hop, and the return migration in the fall have been fully proved in the States, and I have had the privilege of going over and verifying the same facts in the hop-fields of England, during the furlough which I took from the office last fall on account of continued poor health. The experimentation in the way of remedial measures against its attack have also been most successful and satisfactory. The results of the investigation are of such importance and interest that I have been unable to put them together and prepare the necessary illustrations for this annual report, and for these reasons they will appear in separate bulletin form in the spring. In the same way the results of the continued investigations of the Buffalo Gnats, concerning which a preliminary article was published in my last report, are held for future publication.

The work of the Division in carrying out the provisions of the law for the establishment of silk-culture in the United States has entailed quite as much labor during the past fiscal year as in previous years, and the results obtained have been quite as satisfactory as could have been expected under the circumstances. The general scope of the work has included the distribution of Silk-worm eggs and books of instruction and the conducting of experiments with automatic silk-reels, as mentioned in previous reports. The sixth edition of the manual of instructions, "The Mulberry Silk-worm," consisting of 3,000 copies, which was issued in May, 1886, has been practically exhausted and a more enlarged edition is now in the course of preparation. The public interest has centered in the filature, which has been visited by large numbers of persons who uniformally express delight at the experiment. For a full statement of the working of the filature and for other details in reference to the work in silk-culture I refer to the accompanying report of Mr. Walker.

Experiments upon the Fluted or Cottony Cushion-scale of California and the other injurious scale-insects of that State have been continued during the season, and results from the two agents detailed for this purpose are included in this report. To Mr. Coquillett, of Los Angeles, was assigned the duty of experimenting with gases. His report, giving the results of a long series of careful experiments, will prove of interest to the people of California. One of the principal discoveries made by Mr. Coquillett is the fact that hydrocyanic acid gas, when passed through sulphuric acid, is rendered harmless to the foliage of trees confined in it. This will greatly lessen the cost and labor of treating trees with this gas. The experiment with tobacco stems vaporized, an account of which will be found near the end of this report (experiment 128), is worthy of further investigation. Another gas that gives promise of being successfully used as an insecticide is arseniureted hydrogen, which would have the advantage of cheapness as compared with hydrocyanic acid gas; but additional experiments are necessary before its claim can be fully established.

It should always be borne in mind, both in the use of this gas and the hydrocyanic acid gas, that the ingredients are exceedingly poisonous, and the greatest care should therefore be taken by the operator. The history of similar cases of destructive insects introduced from other countries goes to show, however, that the introduction of the natural enemies that keep the Fluted Scale in check in its native country will prove more effective than any other methods in subduing the pest and at the same time relieve the fruit-growers of the large expense attending the employment of even the most satis-

factory remedies. The injuries of this Icerya have so seriously affected the fruit interests of southern California that the leading fruit-growers, in convention assembled, have earnestly petitioned Congress to give you the power to have the natural parasites and enemies of the insect in its native country studied and imported. I have not a doubt that much practical good would result from the study of these parasites in their native country and their introduction to southern California. It would be particularly appropriate to make an effort in this direction in 1888, because of the International Exposition at Melbourne in which this Government will take part. The exposition, in many ways, would further the investigation referred to and asked for by the people of California. The expenses would be trifling if one of the salaried agents of the Division could be employed therefor; but the clause in the appropriation which restricts traveling expenses for the Division of Entomology to the United States precludes the sending of any one without some special law, and I earnestly call your attention to this fact.

Mr. Koebele, stationed at Alameda, has experimented chiefly upon other scale-insects, and he has found that arsenious acid in one form or another is a valuable addition to the kerosene, emulsified with resin compound, as I suggested it would prove to be in my address before the State Board of Horticulture at Riverside last April (see Bulletin No. 15, Division of Entomology). In every instance where the arsenic was added the result was a complete extermination of all scales. He has also obtained excellent results in the application of the dilute resin compound against Plant-lice, including the destructive Woolly Aphis of the Apple (*Schizoneura lanigera*). In the proportion of one part of the compound to eight parts of water it was found that the lice were killed without injury to the beneficial Syrphus larvæ or to the internal parasites of the lice.

The report published from Prof. Herbert Osborn, of Ames, Iowa, relates to some of the more important insects of the season in Iowa. The Turf Web-worm (*Crambus exsiccatus*) has been particularly abundant, and the report contains a good account of its life history and injuries. The Wheat-head Army-worm, the False Chinch-bug, and the injuriousBlister-beetles are also treated of. Prof. Osborn has also sent in a report upon the Chinch Bug (which has been used by Mr. Howard in the general article on the subject), and a report upon observations on Hop insects in Wisconsin, which is reserved for future use. He has also continued to assist me in work on the parasites of domestic animals.

Mr. Bruner's report treats of the damage done by the Chinch Bug in Nebraska, of the condition of the migratory and non-migratory locusts or grasshoppers, and of other less important insects of the season.

Mr. Webster, in addition to an extended report of his observations during the earlier part of the season on the Southern Buffalo-gnat, has submitted some other observations, which are here published. These refer in the main to corn-insects.

These reports as a whole, together with the correspondence of the Division, indicate that, aside from the Chinch Bug and a very few local outbreaks of other species, the year has been one of comparative immunity from insect injuries.

The apicultural experiment station has been changed in location from Aurora, Ill., to Hinsdale, in the same State, the latter location possessing advantages in the way of convenience of transportation

and in other ways. The experiments of the year have been continued on the lines suggested in my last report, and the agent in charge submits in his report the results of his investigations of two important bee diseases, and continues his account of experiments on the control of reproduction.

The colored plates accompanying the report were drawn and colored by Miss Sullivan, under Mr. Howard's supervision.

Respectfully submitted, January 30, 1888.

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner.

THE CHINCH-BUG.

(*Blissus leucopterus*, Say.)

Order HEMIPTERA; family LYGÆIDÆ.

[Plates I and III.]

By L. O. HOWARD, *Assistant.*

INTRODUCTORY.

The present treatment of the Chinch Bug offers little scope for anything new or original. It is an extremely destructive species, which has been exhaustively treated by former writers, and which, after several years of comparative scarcity, has again become very injurious, so much so as to occasion the loss of millions of dollars during the present season and to call forth the greatest variety of comment from the press of the country, agricultural or otherwise. In this emergency it happens that there are no public documents for distribution and even no books which can be purchased which treat of the life history of and remedies for this pest. The State reports of Riley and LeBaron are out of print; the small edition of Bulletin 5 of the U. S. Entomological Commission, by Dr. Thomas, was long since exhausted, and the recent bulletin and circular by Forbes treat almost solely of remedies.

It becomes necessary, therefore, to bring out once more a complete review of the subject; and in the accessible form of this report, 375,000 copies of which are printed, it will undoubtedly receive wide distribution. Previous writings, particularly those of Riley, are freely used, and in many instances the well-known Missouri reports of my chief are quoted at length. Professor Riley's scraps and notes, as also the notes in the Division of Entomology, have been at my disposal.

PAST HISTORY.

It has been quite generally accepted, that the Chinch Bug is, comparatively speaking, a Southern rather than a Northern insect, and in so far as the matter of destructive appearances goes this idea is well upheld by its past history. In our section upon geographical distribution, however, we have shown that the species is by no means confined to the more Southern States, but that it is often found north

of the boundary line in Canada. It was first noticed, so far as we can find, in North Carolina at the close of the Revolutionary war, where, as has has been so often stated, it was mistaken for the Hessian-fly, which at that time was attracting considerable notice on Long Island and thereabouts.

Dr. Fitch, in his second report, gives at some little detail an account of its early appearances, from which we may simply state that after this first notice the insect did considerable damage for several years in North Carolina, South Carolina, and Virginia. After a short series of seasons it was again destructive in North Carolina in 1809, so that in Orange County the cultivation of wheat was abandoned for two years.

In 1839, in the same States, great damage was done to corn and wheat, and in 1840 an increase in number occurred and the wholesale destruction of the crops was only prevented by an exceedingly wet season.

The first scientific description of this species was given by Say in 1831, in a little pamphlet published at New Harmony, Ind., entitled "Descriptions of new species of Heteropterous Hemiptera," from a single specimen collected on the eastern shore of Virginia, and it was probably at that time rare in Indiana where Say resided, at New Harmony.

It attracted much attention in 1840 in Illinois, when it occurred in numbers in Hancock County, where it was supposed to have been introduced by the Mormons, and was called in consequence the "Mormon louse."

According to Professor Riley the first recorded appearance of the insect in Missouri was in 1839. It was again noticed in 1844 and has been destructive ever since. In Iowa its first recorded appearance is in 1847; in Indiana in 1854, and in Wisconsin in 1885.

1864 was a year marked by damage in these Western States. In 1868, a season of great drought, much damage was done by the bugs in Missouri.

In 1871 great damage was done in Illinois, southern Iowa, in parts of Indiana, in Nebraska, in southern Missouri, and Kansas. It was estimated by Dr. LeBaron, in his Second Illinois Report that the loss to the wheat, oat, and barley crops during this year amounted to $10,500,000 in Illinois alone, and in the other six States mentioned, including Indiana, the total loss was upwards of $30,000,000.

In 1874 they occurred again in Missouri and the adjoining States in exceptional abundance. It was during this season that Professor Riley sent out circulars to all parts of Missouri, and at the close of which he wrote the extended article which was published in his Seventh Missouri Entomological Report.

He estimated the total loss to the group of States of which eastern Kansas forms a center to be double that of 1871. Very careful estimates by counties give an aggregate loss of $19,000,000 for Missouri alone, including only the three staple crops of Wheat, Corn, and Oats. He mentions several facts which tend to show that this estimate is low rather than high.

From 1874 to 1881 there were no serious irruptions of this pest, but in this year it attracted considerable notice and did a great deal of damage in the same Western States. Much newspaper literature concerning the insect was published during this year, much of which was excited by Thomas's paper upon the relation of meterological conditions to insect development and particularly to the Chinch Bug.

It was during this year also that the "Chinch Bug convention" was held at Windsor, Kans., and it was decided to exclude wheat from cultivation as a means of extirpating the pest.

In 1882 the work of the bug upon timothy grass was discovered in Saint Lawrence County, N. Y., for the first time in its history. It increased and spread in 1883, exciting great alarm, and occasioned several articles from the pen of Dr. Lintner, who also issued a circular on remedies and anticipating further damage.

Professor Riley, in Science (Vol. II, p. 620), and in his report for 1884 stated that there was little cause for alarm in New York, and, indeed, no particular damage has since been recorded. In 1885 some damage was done in parts of Kansas and Nebraska, and in 1886 still more. Bulletin No. 13 of the Division of Entomology contains reports of considerable damage in the spring of 1886 from Kansas, Indiana, Ohio, and Nebraska, and more especially in southern Illinois.

GEOGRAPHICAL DISTRIBUTION.

East of the Rocky Mountains the Chinch Bug seems to be indigenous North and South, feeding naturally upon various species of wild grasses and becoming multiplied wherever the cultivation of wheat has reached its original haunts.

It was first noticed, as stated in the last section, in North Carolina, and Say's original description was published from a Virginia specimen.

Fitch records the fact that he had collected specimens in New York, but that it was exceedingly rare. Signoret also records it from New York, and, as we have just shown, it appeared in 1883 in destructive numbers in the northern part of this State. Harris, in the first edition of his well-known work, states that it did not occur in New England; but in a foot-note to his second edition states that while the sheet was passing through the press he discovered a single specimen in his own garden at Cambridge (June 17, 1852), and in 1883, according to Dr. George Dimmock (Psyche. Nov., Dec., 1883, p. 119), the lowland between Belmont and Cambridge was swarming with them. They have also been collected by Dr. Packard at Salem, Mass., in Maine, and at the summit of Mount Washington in New Hampshire. Dr. Lintner records the fact that Mr. H. L. Fernald captured one or more specimens in 1879, 1880, and 1882 at Orono, Me.

In Canada they occurred at Grimsby, Ontario, in 1866, and were sent from that point in that year to Mr. Walsh. Mr. W. F. Harrington collected specimens found abundantly at Sidney, Cape Breton (N. lat. 46° 18′), in September, 1884 (Can. Ent., Nov., 1886, p. 218).

Dr. Fitch received specimens from western Pennsylvania, and also stated that it was sent him from Mississippi with the information that in some years it damaged the crops of Indian corn. We have found it personally in considerable numbers in the rice-fields near Savannah, Ga., and Mr. E. A. Schwarz and others have collected it in Florida. In the latter State Mr. Schwarz found it very abundantly at Biscayne Bay, breeding in the wingless form only, in considerable numbers upon sand oats (*Uniola paniculata*). It has also been collected in this same form upon the same plant on the sea-shore at Fortress Monroe, Va., by Messrs. Schwarz and Heidemann. Mr. Webster has noticed it in Mississippi and Louisiana and Professor Riley has seen it in most of the Southern States. The States, however, in which it does the greatest damage are Virginia, North Caro-

lina, South Carolina, Ohio, Indiana, Kentucky, Tennessee, Illinois, southern Wisconsin, Iowa, Missouri, Kansas, and Nebraska. Uhler records the species from Texas, California, Kansas, Nebraska, Wisconsin, Minnesota, Illinois, Michigan, and generally throughout the Atlantic region.

Outside of the United States it is recorded only from Cuba (see Signoret, "Essai Monographique du Genre Micropus, Spinola," Ann. Soc. Ent. France, V, 3d series, 1857, p. 31), and the Cuban individuals are long-winged, while Mr. Schwarz never found a long-winged individual in Florida, in spite of the fact that he has collected in localities the insect fauna of which is in the main Cuban. This observation conflicts with the general observation of Mr. Uhler that the short-winged form seems to be more common in New England than in the Southern States.

The only authentic record of the occurrence of the Chinch Bug west of the Rocky Mountains is the mere mention by Uhler, in his List of the Hemiptera of the Region west of the Mississippi River (Bull. Hayden Surv., I, 306), of California as one of the States which it inhabits, but this record has been overlooked by Californians. Its advent upon the Pacific slope has been expected and dreaded. Matthew Cooke, in his book published in 1883 upon injurious insects of the orchard, vineyard, etc., figured and described it, and under the head of "remedies" wrote: "Should this pest appear in this State it can be prevented, etc."

In June, 1885, there were several newspaper reports on the occurrence of this insect in great numbers in California. The San Francisco Evening Post for June 23, 1885, quoting from the Woodland Democrat, published the statement: "Messrs. Frazee and Henderson, who live southwest of Woodland, brought to this office a bottle of this pestiferous insect (Chinch Bug) on Tuesday. Mr. Henderson says that he recognized them as the same Eastern variety that frequently does so much injury to wheat in Missouri. These gentlemen say they discovered the bugs traveling between the lands of Day and Clanton. There are millions of them, but as to the extent of country covered they are unable to say. The bugs are nearly grown and are just beginning to have wings. As soon as the wings develop they fly and scatter everywhere. Mr. Frazee says there is no danger from them this year as the grain is too far advanced." So far this item seems very plausible, but it goes on to state "that another gentleman had noticed them injure grape-vines," which, of course, introduces a probability of wrong identification.

There is no question, however, but that the Chinch Bug is to be found at present in California, but not the certainty of its existence in injurious numbers. Our certainty as to its presence arises from the fact that a single specimen of a short-winged variety of this insect is among a lot collected in the vicinity of San Francisco in 1885 by Mr. Koebele. It is unquestionably a true Chinch Bug. Another specimen of the same variety was collected in 1884 by some students of Johns Hopkins University, who summered in California, and was given to Mr. Lugger, of this Division, who was at that time connected with the university. Recent communications from California, in answer to inquiries on this point, show that the insect is not known to the entomologists in that State. The False Chinch-bug (*Nysius angustatus*) has been, we learn from Mr. Koebele, very destructive to Grape in that State the past season, and it is more than likely that this is the insect referred to in the newspaper article just

quoted. Mr. Koebele writes that the False Chinch was so abundant around Alameda in July that in an old road at least fifty specimens could be found under each plant of *Polygonum aviculare*. He made in 1887 a most careful search of the locality in which he found the 1885 specimen, but could not find a single additional individual. He also examined the large collection of Hemiptera in the California Academy of Sciences without success. The following paragraph is from Mr. Coquillett's answer to our inquiries:

"I have never met with the Chinch-bug in any part of California that I have visited—neither in Merced County, around the city of Sacramento, nor on the southern part of the State, where I have collected Hemiptera extensively with the sweep-net. Dr. Rivers, curator of the museum at our State University, writes me that three years ago he took three specimens of a bug that that looked much like the Chinch Bug, but was darker and smaller, and he does not believe that they belonged to this species; they were taken in Sonoma County and were sent off he knows not where. He has collected Hemiptera extensively since then, but the Chinch Bug is not among them. Mr. Wickson, editor of the Pacific Rural Press, writes me that he has 'never seen a specimen nor heard of one as being recognized by an observer whom I would consider as capable of recognizing the insect.'"

Since writing the above we have learned from Mr. Uhler that he has seen specimens of the Chinch Bug from California of a long-winged form which were collected near San Francisco, probably by Mr. Hy. Edwards. He has also seen specimens from Cuba and from Tamaulipas, Mexico.

INJURY DURING 1887.

During the present year (1887) the injury was marked in these States and also in some parts of Missouri, but the interesting point in the history of this season has been the occurrence of the insects in great numbers in portions of Virginia and North and South Carolina for the first time in many years, although no considerable damage has been reported to the Department. As a review of the localities and damage this season is desirable we publish a statement by Mr. J. R. Dodge, the Statistician of this Department, who has kindly prepared it at our request.

Mr. Dodge reports as follows:

"In accordance with your request, I take pleasure in communicating the results of inquiries made relative to the geographical distribution of Chinch-bugs during the past season, and to the extent of their destruction of growing crops.

"I find indications of their presence throughout the Southern and Western States, but no material injuries to crops are reported except in States bordering on the Mississippi River and the lower Missouri. Kansas, part of Nebraska, Missouri, Iowa, Illinois, southern Wisconsin, and eastern Minnesota include, practically, the field of their serious operations.

"They attacked wheat and rye first, then barley and oats, and afterward corn, grass, millet, sorghum, and broom-corn. As corn, wheat, and oats are the principal tilled crops of this area, they represent the principal part of the damage.

"In many places the fields were cleared, and small grain areas were plowed up. The pest came in some cases to districts that

had never before been ravaged; in many others the scourge was claimed to be more sweeping than ever before.

"The insect was present in injurious numbers in nearly every county in Kansas. Correspondents in Leavenworth, in the extreme east, and Hamilton, on the Colorado border, gave the only negative replies. The worst damage was done in this State.

"The infliction was general in Missouri except in a belt in the central part of the State, not very regular nor wholly untouched, trending northeasterly and connecting with a similar belt in Illinois.

"Further north, no portion of Iowa was exempt except the northwest corner of the State, in proximity to areas of exemption from central Minnesota westwardly through Dakota, and near to a similar area in northern Nebraska. In eastern Minnesota and southern Wisconsin, however, the scourge was general and severe. In Illinois comparative exemption was enjoyed in a central belt running in a northeasterly direction from Christian to Champaign, and from Adams to Bureau, fifteen to twenty counties, in which correspondents responded in the negative as to their destructive presence. Elsewhere the pest was nearly universal.

"The southwestern corner of Indiana was alive with Chinch-bugs; elsewhere, though present in much of the area, only about a dozen counties estimated any material losses. They were still scarcer in Michigan. Only ten counties in Ohio reported their injurious presence; and a few only in Kentucky indicated material damage.

"These insects are reported as more or less injurious in every season of drought and scarce or absent in all wet areas. They have attacked almost every crop, though giving their preference to the cereals. In the area of their depredations, the crops have an annual value of more than a fourth of the entire agricultural production of the United States, and a value nearly four times as great as that of the cotton crop. It will readily be seen that the losses must be heavy, undoubtedly greater than those of all other insects together, as no such values are involved in other crops subject to insect depredations the past year.

"The following table has been prepared from data severely scrutinized, revised, and accurately consolidated. It makes a large sum, and yet does not comprise all the damage done to barley and rye, millet, etc., all of which might be approximately stated in round numbers as $60,000,000. The record by States is as follows:

States.	Corn.		Wheat.		Oats.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.
Kentucky	983,280	$521,138	66,678	$48,675	....	....
Ohio	885,564	425,071	215,370	161,528	60,196	$19,263
Indiana	1,785,000	803,250	453,936	326,834	167,658	48,621
Illinois	16,929,600	6,941,136	5,529,150	3,870,405	3,810,310	1,028,784
Wisconsin	1,804,250	757,785	3,004,490	1,922,874	1,742,750	487,970
Minnesota	2,169,720	802,796	9,074,750	5,354,103	2,438,160	633,922
Iowa	22,020,240	7,707,084	6,977,620	4,256,348	4,462,920	1,071,101
Missouri	15,504,390	5,736,624	1,664,640	1,032,077	795,860	206,924
Kansas	16,840,340	6,230,926	2,282,100	1,392,081	6,406,560	2,438,497
Total	78,922,384	29,925,810	29,268,734	18,364,925	19,884,414	5,935,082

Accompanying these statement of Mr. Dodge were nine State maps indicating the counties reporting to the Department damage from

the Chinch Bug. Many other localities had Chinch Bugs in abundance, and considerable damage was done in States not represented in this list. These localities, however, are authoritative, and their reports furnished the main basis for the table which preceeds. We may summarize these briefly as follows :

Illinois, fifty-one counties, as follows: Stephenson, Winnebago, Lake, Carroll, Lee, Kendall, Will, La Salle, Rock, Mercer, Warren, Stark, Iroquois, Vermilion, Edgar, Douglas, Coles, Moultrie, Shelby, Cumberland, Clark, Jasper, Effingham, Fayette, Bond, Madison, Macoupin, Greene, Pike, Jersey, Saint Clair, Clinton, Washington, Marion, Clay, Lawrence, Wabash, Edwards, White, Hamilton, Franklin, Randolph, Jackson, Williamson, Saline, Gallatin, Johnson, Pope, Hardin, Massac, and Alexander.

Indiana, twenty-five counties, as follows : Elkhart, Jasper, White, Huntington, Wells, Blackford, Jay, Warren, Montgomery, Wayne, Shelby, Johnson, Sullivan, Greene, Dearborn, Knox, Martin, Ohio, Gibson, Pike, Dubois, Posey, Vanderburgh, Warrick, and Spencer.

Iowa, sixty-one counties, as follows: Winnebago, Worth, Mitchell, Howard, Winneshiek, Allamakee, Clayton, Fayette, Chickasaw, Floyd, Cerro Gordo, Hancock, Palo Alto, Pocahontas, Humboldt, Franklin, Dubuque, Buchanan, Grundy, Hamilton, Webster, Calhoun, Sac, Crawford, Carroll, Greene, Story, Marshall, Tama, Benton, Linn, Jackson, Clinton, Scott, Muscatine, Iowa, Jasper, Dallas, Guthrie, Audubon, Shelby, Madison, Mahaska, Keokuk, Des Moines, Henry, Monroe, Lucas, Union, Adams, Montgomery, Mills, Fremont, Page, Taylor, Decatur, Wayne, Appanoose, Davis, Van Buren, and Lee.

Kansas, sixty-three counties, as follows: Cheyenne, Rawlins, Norton, Phillips, Jewell, Washington, Marshall, Nemaha, Brown, Wyandotte, Jefferson, Jackson, Shawnee, Douglas, Pottawatomie, Riley, Wabaunsee, Davis, Clay, Cloud, Mitchell, Rooks, Graham, Sheridan, Thomas, Sherman, Gove, Russell, Lincoln, Ottawa, Ellsworth, Saline, Dickinson, Morris, Osage, Franklin, Miami, Linn, Anderson, Coffey, Chase, Marion, McPherson, Rice, Barton, Rush, Ness, Lane, Scott, Ford, Pawnee, Stafford, Reno, Sedgwick, Allen, Neosho, Cherokee, Labette, Chautauqua, Cowley, Sumner, Barbour, and Comanche.

Michigan, five counties, as follows: Manitou, Presque Isle, Saginaw, Shiawassee, and Saint Joseph.

Kentucky, eight counties as follows: Carroll, Pendleton, Bracken, Estill, Mercer, Union, Ballard, and Marshall.

Minnesota, twenty-seven counties, as follows: Hubbard, Wadena, Todd, Crow Wing, Kanabec, Pine, Isanti, Chisago, Sherburne, Stearns, Wright, Carver, Scott, Rice, Wabash, Winona, Olmstead, Dodge, Steele, Waseca, Watonwan, Martin, Faribault, Freeborn, Mower, Fillmore, and Houston.

Missouri, sixty counties, as follows: Atchison, Nodaway, Holt, Worth, Gentry, Harrison, Mercer, Putnam, Sullivan, Adair, Linn, Clinton, Caldwell, Ray, Chariton, Randolph, Lincoln, Saint Charles, Callaway, Cooper, Johnson, Cass, Bates, Henry, Saint Clair, Hickory, Osage, Maries, Gasconade, Franklin, Jefferson, Washington, Saint Genevieve, Perry, Iron, Bollinger, Cape Girardeau, Mississ.ppi, New Madrid, Butler, Wayne, Oregon, Shannon, Pulaski, Laclede, Wright, Douglas, Ozark, Christian, Webster, Dallas, Hickory, Polk, Cedar, Dade, Barton, Lawrence, Barry, Newton, and McDonald.

Ohio, ten counties, as follows: Defiance, Wood, Geauga, Allen, Shelby, Darke, Franklin, Fairfield, Meigs, and Gallia.

FOOD PLANTS.

The Chinch Bug will feed upon all grains and grasses so far as known. The most prominent crops which are seriously injured are Wheat, Barley, and Indian Corn. The testimony in regard to Oats is conflicting, but LeBaron's conclusion to the effect that "if this grain be sown where Chinch Bugs abound, and especially if it is sown exclusively it will be damaged to a greater or less extent the first year, but that the bugs will probably not continue to breed in it to any great extent in succeeding years," is unquestionably correct. Broom-corn, Sorghum, Chicken-corn, Hungarian grass, Millet, Rye, rice, Bermuda-grass (*Cynodon dactylum*), Fox-tail grass (*Setaria glauca*), Timothy (*Phleum pratense*), Blue-grass (*Poa pratensis*), Crab-grass (*Panicum sanguinale*), Bottle-grass (*Setaria viridis*), *and*

all of our wild grasses, so far as known, are attacked, but beyond these no plant is ever damaged. Reports of damage done to other crops, such as grape-vines and garden crops, are the results of mistaken identity, and an error in the compilation of Packard's Guide to the Study of Insect has doubtless done much to perpetuate the idea that this insect is a more general feeder. This was corrected in the later editions of this work, probably at the suggestion in Professor Riley's criticism in his Seventh Rept. Ins. Mo., page 26.

Upon the Sand Oats (*Uniola paniculata*) in Florida Mr. Schwarz noticed that the entire development of the insect is undergone upon the highest part of this tall plant, and not close to the bottom as in our latitude. The probable reason for this, as he has pointed out, is that the strong winds are continually blowing fine, sharp sand through the lower parts of the plants, rendering it impossible for the bugs to remain at these places and forcing them to seek their nourishment higher up.

Concerning Timothy and the Crab-grasses Professor Forbes says: "It seems to prefer Timothy to Blue-grass, not really relishing either as a general thing, and takes to the Crab-grasses (*Panicum*) not at all, or only as a last resort" (Bull. No. 2, State Ent. Ill.). This generalization is undoubtedly correct for Illinois and the surrounding States, but, as Professor Forbes himself points out in a foot-note, the bugs did great damage to Timothy in northern New York in 1883, and the following extract from a letter recently received from Professor Atkinson, of North Carolina, indicates that in that State at least the Crab-grass becomes an important item of the insects' diet: "* * * I have recently discovered that at this season of the year (October) the Chinch Bug feeds on the 'crab-grass,' so common in cultivated and waste places, and especially so abundant in many of the corn-fields after cultivation has ceased. The Chinch-bug must go to the grass after the corn becomes mature and no longer yields the sap. I have found the bugs inside the sheath and clear evidence of their having punctured the colon. No doubt this grass affords them subsistence for quite a period of time, and then shelter for the winter. * * * I have found within the past few days pupæ, or wingless individuals, in the Crab-grass. * * *" Referring again to Timothy, we may state that a meadow of this grass on the farm of J. F. Whiton, near Wakeman, Huron County, Ohio, was injured considerably by the bugs in 1886. Professor Forbes, however (Bull. 2), gives an instance where sowing Timothy with fall wheat was probably the cause of the salvation of the crop.

On cultivated Rice we found Chinch Bugs very generally scattered throughout the large rice-fields near Savannah, Ga., in August, 1881. Only adult specimens were found at that time, and all were fully winged and were found upon the heads of the grain, to which they had probably flown, as the fields had been flooded for some time previously. No particular damage to the crop was perceptible, unless their punctures contribute to bring about the disease known as "white blast," as suggested by Professor Riley in his Annual Report for 1881–'82, p. 137.

We shall probably be obliged to widen our close restriction of the Chinch Bug food plants, to admit at least one of the Polygonums. A chance statement by Mr. Bruner that he had known this insect to feed upon the so-called "Wild Buckwheat" in Nebraska led to a letter of close inquiry, to which he replied that there can be no mistake and that the plant is either *Polygonum dumetorum*, or *P. convolvulus*.

STAGES OF GROWTH—DESCRIPTIVE.

The following descriptive matter is from Professor Riley's Seventh Report on the Insects of Missouri, and is fuller and more careful than that published elsewhere. It will be noticed that there are three larval stages, necessitating two molts before the pupa and three before the adult. It will also be noticed that the larvæ have but two joints to the feet, while the adults have three:

THE EGG (Plate I, fig. 2). Average length 0.03 inch, elongate-oval, the diameter scarcely one-fifth the length. The top squarely docked and surmounted with four small rounded tubercles near the center. Color when newly laid, pale and whitish, and translucent, acquiring with age an amber color, and finally showing the red parts of the embryo, and especially the eyes toward the tubernacled end. The size increases somewhat after deposition, and will sometimes reach near 0.04 inch in length.

LARVAL STAGES.—The newly-hatched larva is pale yellow, with simply an orange stain on the middle of the three larger abdominal joints. The form scarcely differs from that of the mature bug, being but slightly more elongate; but the tarsi have but two joints (Fig. 4, *d*), and the head is relatively broader and more rounded, while the joints of body are sub-equal, the prothoracic joint being but slightly longer than any of the rest. The red color soon pervades the whole body, except the first two abdominal joints, which remains yellowish, and the members, which remain pale. *After the first molt* the red is quite bright vermilion, contrasting strongly with the pale band across the middle of the body; the prothoracic joint is relatively longer, and the metathoracic relatively shorter (Plate I, fig. 3). The head and prothorax are dusky and coriaceous, and two broad marks on mesothorax, two smaller ones on metathorax, two on the fourth and fifth abdominal sutures, and one at tip of abdomen are generally visible, but sometimes obsolete; the third and fourth joints of antennæ are dusky, but the legs still pale. *After the second molt* the head and thorax are quite dusky and the abdomen duller red, but the pale transverse band is still distinct; the wing-pads become apparent, the members are more dusky, there is a dark red shade on the fourth and fifth abdominal joint, and, ventrally, a distinct circular dusky spot covering the last three joints (Plate I, fig. 4).

PUPA (Plate I, fig. 5).—In the pupa the coriaceous parts are brown-black; the wing-pads extend almost across the two pale abdominal joints, which are now more dingy, while the general color of the abdomen is dingy gray; the body above is slightly pubescent, the members are colored as in the mature bug, the three-jointed tarsus is foreshadowed, and the dark horny spots at tip of abdomen, both above and below, are larger.

IMAGO (Plate I, fig. 6).—The perfect insect has been well described, and I will append the original descriptions:

"Lygæus Leucopterus (Chinch-bug). Blackish, hemelytra white, with a black spot.

"Inhabits Virginia.

"Body long, blackish, with numerous hairs. Antennæ, rather short hairs; second joint yellowish, longer than the third; ultimate joint rather longer than the second, thickest; thorax tinged cinereous before, with the basal edge piceous; hemelytra white, with a blackish oval spot on the lateral middle; rostrum and feet honey-yellow; thighs a little dilated.

"Length less than three-twentieths of an inch.

"I took a single specimen on the eastern shore of Virginia.

"The whiteness of the hemelytra, in which is a blackish spot strongly contrasted, distinguishes this species readily." (Say, Am. Entomology, I, p. 329).

The above description originally appeared in 1832, in a pamphlet entitled "Descriptions of new species of Heteropterous Hemiptera of N. A."

"Length, 1⅝ lines, of three-twentieths of an inch. Body black, clothed with a very fine grayish down, not distinctly visible to the naked eye; basal joint of the antennæ honey-yellow; second joint of the same tipped with black; third and fourth joints black; beak brown; wings and wing-cases white; the latter are black at their insertion, and have near the middle two short, irregular black lines and a conspicuous black marginal spot; legs dark honey-yellow; terminal joint of the feet and the claws black." (Dr. William LeBaron, in the Prairie Farmer for September, 1850, Vol. X, pp. 280, 281, where the name of *Rhyparochromus devastator* is proposed for it).

Dr. Fitch also enumerates the following varieties of this insert:

(*a*) *immarginatus*.—Basal of the thorax not edged with yellowish. Common.

(*b*) *dimidiatus*.—Basal half of the thorax deep velvety black, anterior half grayish. Common.

(*c*) *fulvivenosus*.—The stripes on the wing-covers tawny yellow instead of black.

(*d*) *albivenosus*.—Wing-covers white, without any black marks except the marginal spot. A male.

(*e*) *apterus* (Plate I, fig. 7.—Wingless and the wing-covers much shorter than the abdomen.

(*f*) *basalis*.—Basal joint of the antennæ dusky and darker than the second.

(*g*) *nigricornis*.—Two first joints of the antennæ blackish.

(*h*) *femoratus*.—Legs pale livid yellow, the thighs tawny red. Common.

(*i*) *rufipedis*.—Legs dark tawny red or redish brown.

To these varieties, all of which occur with us, I would add one which may be known as *melanosus*, in which the normal white of the wings is quite dusky, and contains additional black marks at base and toward tip, and in which all the members and the body except the rufous hind edge of thorax are jet black.

In addition to these varieties mentioned by Dr. Riley, an interesting form has been collected by Mr. E. A. Schwarz, at Lake Worth, Fla., and by Mr. O. Heidemann, at Fortress Monroe, Va. This variety is illustrated on Plate I at Fig. 8, and is at once distinguished from other short-winged varieties by its more slender and pointed wing-pads and by the color of the antennæ, the first three joints of which are honey-yellow, while the last joint or club is nearly black. It seems also to be more thickly clothed with silvery pile, but this is probably due to the fact that the specimens studied were mounted dry, while all others which I have seen have evidently been placed in alcohol. This variety, so far as we know, has been collected on the sea-shore only.

NUMBER OF BROODS AND HIBERNATION.

For many years there existed a misconception concerning the number of broods of this insect in the West. It was always understood that there was more than one brood, and some newspaper writers insisted that there were as many as five or six annual generations. Professor Riley, in the Practical Entomologist, Vol. I (March 26, 1866), was the first to publish the definite statement that the Chinch Bug is two-brooded in northern Illinois, and Dr. Shimer, the succeeding year, published the same statement from his own observations. This number of annual generations holds through the entire Northwest and as far south certainly as the latitude of Saint Louis. Thomas states that there is some evidence of an occasional third brood in the extreme southern part of Illinois and in Kentucky, but that it is not sufficient to justify him in stating it as a fact, or to satisfy him of its correctness. In North Carolina there seems no question but that the second generation gave birth to still a third, which, as we are informed by Professor Atkinson, of Chapel Hill, was found in a half-grown condition on Crab Grass about the 1st of October. This third generation probably hibernates in the adult condition.

The Chinch Bug passes the winter in the perfect state. As cold weather approaches most of the full-grown bugs leave the hardened corn-stalks or wild grasses upon which they have been attempting to feed and seek some convenient shelter in which to pass the winter. They collect in fence cracks, in sheds, hay-stacks, straw-stacks, corn-shucks, under leaves, mulching, and rubbish of all kinds upon the ground, under the loose bark of adjacent trees, in stumps and logs, under stones and clods of earth, in fact, in any situation which will

offer shelter. They seem to prefer dry situations. Bunches of old dead grass and weeds offer them particularly attractive places for hibernation. Professor Atkinson writes us that the Crab Grass in North Carolina not only affords the bugs sustenance after the corn-stalks harden, but also gives them shelter for the winter, as they work their way down between the leaf-sheath and the stalk. Mr. J. O. Alwood writes us from Columbus, Ohio, that October 26, 1887, he observed them lying torpid within the leaf-sheaths of an uncut field of Pearl Millet. During cold weather they remain torpid. On a warm, sunshiny day they will stretch their legs and begin to move about to a slight extent; but as the cold becomes severe they press back deeper into their hiding-places. They can withstand the severest cold, and, in fact, as with so many other hibernating insects, the more sustained the cold weather the more the insects winter successfully. An instance is related by a reliable correspondent of Dr. Thomas in which the bugs frozen into ice were thawed, and when warm manifested signs of life, crawling back as in the spring. Dr. Shimer's observations upon this point are sufficiently interesting to quote:

After the early autumn frosts they left their feeding-grounds on foot in search of winter quarters; none could be seen on the wing as at harvest time. For a winter retreat they resorted to any convenient shelter they might chance to find, as long grass, weeds, boards, pieces of wood, rails, fallen tree leaves, etc.

In January, 1865, I next examined their condition; those that I found in the sheaths of the corn-leaves above the snow, and had been thus exposed during the previous severe weather, when for several successive days the thermometer was 15° to 20° below zero, were invariably found dead, without exception, and those beneath the snow were alive. This observation was made in the common farm corn-fields, as they might be found anywhere all over the wide country, for in autumn the Chinch-bugs remained in great numbers in the corn-husks and under the sheaths of the blades, as well as in other winter retreats. Upon various occasions, as the winter advanced, I brought in corn-husks filled with ice, inclosing the Chinch-bugs in the crystallized element; when the ice was thawed they were able to run, apparently unaffected by that degree of cold. It is therefore proved that these insects possess vitality sufficient to withstand the effect of a temperature below the freezing point, and perhaps below zero, as must have been their condition in these ice-bound husks; but when in the open air, exposed to the sweeping prairie winds, 15° to 20° below zero for a long time, they succumb to the cold.

March 7, 1865.—The snow having cleared off from the ground I examined the condition of a host of these Chinch-bugs that had chosen for their winter covering cord-wood sticks lying on the ground, entirely surrounded by frost and ice. Of these 20 per cent. were living; those that were more fortunate in their selection of winter quarters fared much better. From a single handful of leaves picked up at one grasp from beneath an apple tree I obtained 355 living and 312 dead Chinch-bugs; and of their lady-bird enemies that had entered the same winter quarters with them, 50 were living and 10 dead. Of these Chinch-bugs I placed a number in comfortable quarters in the house in a small pasteboard box—not in a stove room—together with some coleopterous insects casually gathered among the Chinch-bugs; after one month I found the latter all dead and the former living.

The entire month of March was rain, snow, thawing, freezing, alternately, seeming to be very uncomfortable for any living creature to remain out of doors with so poor a shelter and on top of the ground.

April 1–6.—I again made repeated examinations of these Chinch-bugs in their winter quarters, and found about the same proportion of them living as noted on the 7th of March. At this time they wandered away on foot from their winter quarters.

Mr. G. A. Waters, in the Farmer's Review for October 19, 1887, gives the following interesting observation bearing on the same point:

"In 1881–'82 I observed a bunch of fodder that had fallen into a ditch that the heavy rains had washed near by a shock. The fodder had been overflowed with water, which had stood over the fodder long enough for a sheet of ice to form over it, the water subsiding

in a few days and some thaw occurring, I pulled the stalks out of the mud to get the ears of corn off, and in husking the ears found quite a number of Chinch Bugs which had been immersed for a week or more. On exposing them to the warm sun they crawled around lively."

Where they are hibernating in numbers they can often be detected more readily by their strong "bed-buggy" odor than by sight, as was pointed out by Dr. Riley. Dr. Lintner, in October, 1883, found this method of searching for them "more convenient and infallible than looking for them."

Mr. Bruner calls our attention to the fact that the Osage and other brushy hedges in the West are great collectors of leaves and trash, blown there by the winds, and that they form exceptionally good hibernating places for the Chinch Bugs, which take advantage of them in great numbers. So great a nuisance are the hedges from this point of view that Mr. Bruner seriously advocates their gradual removal and the substitution of a less compact division between fields.

HABITS.

With the warm days of spring the hibernating individuals issue from their winter quarters and copulate. Dr. Shimer has described a love-flight which he noticed at this time. The date was May 16, 1865, and the atmosphere was swarming with Chinch Bugs on the wing. As shown by Walsh and Riley (Am. Ent., I, 173), it is probable that this occurrence was exceptional, and that the insects do not normally mate in this way; that the swarming flight was the result of a great abundance of the insects. The insect flies in spring and fall and also somewhat in late July and early August as the first brood becomes winged. In the fall they attain wings as the corn hardens and their flight is then the result of a starvation impulse. In July and August the flight of the fledged individuals of the first brood is not very common, except when they occur in exceptionally great numbers. During the past season Professor Osborn observed them coupling at Ames prior to July 25, while upon this date he observed them swarming in the air, flying past his window in immense numbers and with the wind (southeast to northwest). They were first noticed shortly after 1 p. m. July 27 they were again noticed on the wing, but not in such great numbers as before. They were flying with the wind from northwest to southeast. August 3 hosts of them were observed on the wing, while others were coupling on the ground. Others were observed coupling as late as August 16.

The majority of the hibernating individuals seem, from the evidence, to copulate in the spring and without flying, but according to Professor Riley many of them make love in the fall preparatory to seeking winter quarters, and Mr. James O. Alwood, of Columbus, Ohio, writes that he found them copulating in the field of uncut Pearl Millet at the Ohio Agricultural Experiment Station as late as October 27, 1887.

The eggs of the Chinch Bug, which we have already described, and which are figured on Plate I, Fig. 2, are laid in the spring for the first brood, and usually underground and upon the roots of plants infested. They are, however, often found above ground upon the withered sheaths near the bases of the grain stalks, or often upon the blades of the leaves. They are deposited in small clusters, like those shown upon the plate.

Professor Riley says: "A wheat plant pulled from an infested field in the spring of the year will generally reveal hundreds of these eggs attached to the roots, and at a somewhat later period the young larvæ will be found clustering on the same and looking like so many moving atoms." The eggs are not specially small, and when we consider the small size of the female which lays them (Dr. Shimer says that each female lays 500) this seems very large, until we reflect that they are not all deposited at once, and that after the laying of the first few others are probably developing in the ovaries, for the process of oviposition occupies from ten days to three weeks. It has long been known that the eggs were laid in the ground, and an accurate description was given by Professor Riley as early as 1866. The relative abundance of the eggs upon the stalk and upon the roots may be changed somewhat, as Dr. Thomas has pointed out, by the character of the soil. Where the soil is very damp the majority of the eggs are doubtless laid upon the stalks, whereas if the earth is dry and easily penetrated the great majority of them will be found upon the rootlets and upon the stalks beneath the ground.

According to Professor Riley the eggs hatch, on the average, in two weeks. The young larvæ begin to take nourishment as soon as possible after hatching. They insert their beaks sometimes even before they emerge from the earth, but more often crawl up the stalk, before beginning to pump. They grow with considerable rapidity, and swarm over the stalk upon which they were born, walking about with ease, and wandering from one stalk to another if occasion demands. As we have already shown, four molts are undergone before the insect reaches the perfect state, and generally from five to seven weeks elapse from the hatching to the final molt. Dr. Shimer's repeated observations show that at Mount Carroll, Ill., the imago usually appears in from fifty-seven to sixty days after the laying of the eggs and about forty-two days from the hatching of the larvæ. By the time the majority of the insects of this first generation are full grown, or even before, the wheat has become too hard to offer them much nourishment, or harvest time has arrived, and they begin to migrate in search of food. Neighboring cornfields offer a more tempting diet, and in seasons of great abundance they march in numerous colonies, moving by a common impulse from the wheat to the corn. Strange to say, although the commoner form possesses wings the insect does not generally take flight, but prefers to walk along the ground. Occasionally, however, at this time they take wings and scatter. This, however, is rarer when the insects are plentiful than when they are comparatively scarce. Under no circumstances will these insects take to flight to escape danger.

Dr. Shimer says: "No threatening danger, however imminent, whether of being driven over by grain-reapers, wagons, or of being trodden under foot, will prompt it to use its wings to escape. I have tried all imaginable ways to induce them to fly, as by threshing among them with bundles of rods of grass, by gathering them up and letting them fall from a height, etc., but they invariably refused entirely to use their wings in escaping from danger." The migration takes place often and, according to some authors, usually before the majority of the broods have attained full growth. There are always many immature individuals among a large host, and often the army is composed almost entirely of such. In fact, at these times there is apt to be a general confusion of so-called larvæ, pupæ, and adults, owing

to the fact that some hibernating females oviposit much in advance of others and to the other fact, previously mentioned, that a single female takes several days or even weeks to lay all of her eggs. Professor Forbes records egg-laying, presumably by hibernating individuals, from the last week in May (at Decatur) until the last week in June (at Warsaw), thus making certain individuals of the first brood one month later in development than others in two localities not far distant (140 miles) and of about the same latitude. There are many accounts in print which are almost incredible tales of the size of these migrating hordes, and yet they are probably only too true.

Dr. Thomas states that the migration upon foot seldom exceeds 80 rods, but the winged individuals fly to much greater distances. Instance was given in the Farmer's Review for August 17, 1887, where a little patch of sweet-corn grown in the midst of pine woods in northern Wisconsin, 8 miles from a cultivated crop of any kind, was badly infested with the Chinch Bug. This appearance of the bugs probably resulted from the flight thereto of mature individuals.

It naturally results from the wide difference in the method of growth of the crops that the Chinch Bugs, after migrating from wheat to corn, appear to be much more numerous upon the latter crop than they were upon the former, in spite of the great numbers usually killed in the act of migrating, for a single stalk of corn will be obliged to support the Chinch Bugs from a great many stalks of wheat. Moreover, the bugs swarm upon the first few rows and destroy them before invading the entire field generally. The outer rows, of course, under these circumstances are often black with bugs. The pupæ work their way down between the leaves and the stalk and there cast their skins and issue as adult insects. The leaf sheath is often thus filled with exuviæ. The eggs for the second brood are also often, if not usually, deposited in this same situation—behind the sheaths of the lower leaves—and on hatching the young bugs remain there feeding and growing and casting skins, sometimes even until the advent of cold weather and their consequent winter torpor. Others issue from these sheaths, particularly when they are especially abundant, or, failing to find satisfactory locations on the outer rows, take wings and fly to the center of the field and become generally scattered. They feed upon the Corn or Rye, as the case may be, and upon the surrounding grasses or in the fields of Millet or Hungarian grass until the approach of fall, by which time nearly all are once more full-grown. Mr. Webster observed them at La Fayette, Ind., in August, forcing themselves down into cut stubble of Foxtail Grass (*Setaria glauca*) for the purpose of undergoing the last molt. He counted upwards of twenty in a single stalk.

We may mention in this connection, as reported to us by Professor Osborn and also as published in the Country Gentleman for August 25, 1887, that President Chamberlain, of the Iowa Agricultural College, dug a single root of Hungarian grass at Ames, Iowa, the first week in August, upon which were counted 3,025 bugs. Earth was removed with the root to the depth of 3 inches (1 inch surface), in all about 4 cubic inches.

In the North the majority of them are ready to hibernate by the time the field corn is harvested. Farther South, however, the corn grows too hard for them a considerable time before the weather is cold enough to compel them to seek winter shelter. In North Carolina, as we have already shown, a third brood has appeared by the time the corn becomes hard and the bugs seek the Crab-grass and

there feed until ready for hibernation, finding in this grass, moreover, good shelter for the winter.

The general statements here given apply to the average Chinch-bug year in Illinois, Missouri, and the surrounding States, as the articles from which we have drawn our main facts are the results of observations made in these States. The life history and habits of the species undoubtedly differ considerably in the more southern States, where, however, it seldom does much damage. It is very doubtful, however, that the habits differ so greatly as to admit of the correctness of the statement quoted by Fitch from the Southern Planter (XV, 269) that the eggs are laid in the ground in autumn, where they remain through the winter and until the warmth of the ground the following year causes them to hatch! This great error (at least for the West and North) is unfortunately perpetuated by Dr. Lintner in his second report as State Entomologist of New York, p. 153.

There seems, in fact, every reason to suppose that this was simply a guess on the part of the editor of the Southern Planter, without the slightest observation to substantiate it. At our request Professor Atkinson examined a number of females found near Chapel Hill, N. C., in November, but found no evidence of mature eggs. He also searched carefully for deposited eggs with, of course, negative results. He states that Mr. Thomas S. Weaver, of Chapel Hill, has observed the bugs for the past ten years, and states that they never deposit in autumn.

In exceptional seasons and under exceptional conditions the life history and habits will vary considerably even in the localities referred to; for example, in 1882, according to Professor Forbes' first Illinois report, there was evidently in some parts of the State but one brood, and the first young bugs were not seen before July 10. The eggs of the *first* brood were in some localities this season laid upon corn.

NATURAL ENEMIES AND DISEASES.

INSECT ENEMIES.—No true internal insect parasites of the Chinch-bug have yet been found. In fact, very few of the smaller Heteroptera are parasitized except in the egg state. The minute Proctotrupidæ belonging to *Teleas* and *Telenomus* infest the eggs of allied species and may ultimately be found to attack the eggs of the Chinch Bug. Outside of these genera, however, we can hardly expect any aid from parasitic insects. In this connection, although it does not strictly come under this head, we may mention that in 1885 Mr. Webster found a species of Mermis ("hair snakes") among the dried moultings and dead bodies of certain Chinch Bugs in a stalk of Setaria, which gives rise to a strong probability that one of these creatures will be found to infest the bug. Many predaceous insects destroy them, although their disgusting odor is probably more or less a protection.

Mr. Walsh, in 1861, mentioned four Lady-birds, viz, the Spotted Lady-bird (*Hippodamia maculata*, Plate III, fig. 6), the Trim Lady-bird (*Coccinella munda*, now called *Cycloneda sanguinea*, Plate III, fig. 4), and two species of *Scymnus*. In 1882 Professor Forbes found five species of Lady-birds (including the first two mentioned by Walsh) extremely abundant on corn (15 or 20 to a hill) which was infested by hosts of Chinch Bugs. The contents of the stomachs of a few specimens of each were examined, with the following re-

sults: In three specimens of *Hippodamia maculata* no traces of Chinch Bugs were found, the food consisting of the spores of lichens, the pollen of Rag-weed, and traces of plant-lice. One-third of the food of *Hippodamia convergens* (Plate III, fig. 7), (5 specimens examined) consisted of equal parts of Chinch Bugs and plant-lice. In four specimens of *Hippodamia glacialis* 8 per cent. of the food was found to be Chinch Bugs, 18 per cent. plant-lice, and the rest vegetation. A single specimen of *Coccinella 9-notata* had eaten no insect food. Three specimens of *Cycloneda sanguinea* had eaten some plant-lice, but no Chinch Bugs. From these observations Professor Forbes concludes that it is possible that the Lady-birds were attracted "rather by the stores of fungi in the field than by the Chinch Bugs and plant-lice."

The Weeping Lace-winged Fly (*Chrysopa plorabunda*, Fitch, Plate III, fig. 11), described originally by Dr. Shimer as *Chr. Illinoiensis*, has been found by Dr. Shimer to destroy the Chinch Bug. Professor Riley records the fact that the Insidious Flower-bug (*Triphleps insidiosus*, Say, Plate III, fig. 12), an insect which is often found in company with the Chinch Bug and which has been mistaken for it in reality, feeds upon the pest. This is the insect which was sent to Dr. Fitch as a Chinch Bug and which he described as *Anthocoris pseudochinche* in his second report. Professor Riley also records the fact that he has observed the Many-banded Robber (*Milyas cinctus*, Fab. Plate II', fig. 8) in the act of preying upon the Chinch Bug, and Dr. Thomas considers this insect the most efficient of the insect enemies of the pest.

Two of Professor Riley's correspondents, in 1874, stated that ants destroyed the eggs of the Chinch Bugs, but the observation lacks scientific confirmation. Professor Forbes, in 1882, observed a small ant (*Lasius flavus*) in extraordinary numbers in fields of Broom-corn and Sorghum, and both he and a farmer, whom he does not mention by name, made each an independent observation upon an ant which was carrying off a Chinch Bug in its jaws, but repeated dissections of Ants found in such fields failed to show that they had fed on the bugs.

Professor Forbes, in his 1882 report, adds to the list of observed insect enemies a common Ground-beetle—*Agonoderus pallipes* (*comma*), Fabr. (Plate III, fig. 10) of which, upon dissection, one-fifth of the total food was found to be Chinch Bugs. This is the insect figured upon Plate I of Bulletin 12 of the Division of Entomology, and which is there stated to destroy seed-corn in the ground, so that its beneficial qualities are offset by its injurious tendencies.

The evidence of Dr. Shimer, Mr. Walsh, and others is quite sufficient to establish the fact that the Lady-bird and the Lace-winged Fly mentioned will feed upon the Chinch Bug, and Dr. Shimer's evidence in favor of the latter insect is particularly strong. His testimony as to the great abundance of the Lady-birds upon corn infested by Chinch Bugs is, of course, only presumptive evidence of their good work in destroying this insect. It is unquestionable, however, that the Lady-birds prefer plant-lice to the Chinch Bugs, and in at least one instance which has been reported to us, when the Lady-birds were present upon corn in considerable numbers and when this crop was infested by the Chinch Bug, a careful study by the observer (Mr. Lawrence Bruner) showed that the Corn Aphis was also present and that the Lady-birds were feeding upon these latter, and did not, so far as he could see, touch the Chinch Bugs. Professor

Forbes' stomach examinations, previously mentioned, also tend to cast discredit upon the Lady-birds as Chinch Bug destroyers.

VERTEBRATE ENEMIES.—Professor Riley published many years ago, in the Prairie Farmer, the fact that the common Quail or "Bob White" (*Colinus virginianus*) was a most efficient destroyer of the Chinch Bug, and this fact has since been confirmed by other writers.

Dr. Riley says: "In the winter time, when hard pushed for food, they must devour enormous numbers of the little pests, which winter in just such situations as are frequented by the quail; and this bird should be protected from the gun of the sportsman in every State where the Chinch Bug is known to run riot." We may add the corroborative evidence of Mr. Bruner, who as a taxidermist has had special opportunities for studying the habits of the quail.

"Protect the birds, and, above all, the quails; for they destroy countless numbers of hibernating insects of various kinds that are to be picked up about the hedges and such like resorts frequented by these birds throughout the winter. Although belonging to the gramnivorous birds, the quail is essentially insectivorous, except in inclement weather, when the latter are not easily to be obtained. In my profession as taxidermist I have dissected many different species of birds, in the crops of which were contained injurious insects of various kinds, the Chinch Bug among others. In no other instance do I remember of the presence of this insect in the crop of a bird in so great numbers as in that of the Quail. As a rule but few birds, mammals, reptiles, or rapacious insects seem to relish any of the odoriferous members of the Hemiptera or true bugs. In winter, however, this repugnance is partially overcome, and now and then even a Chinch Bug seems a delicate morsel when 'meat' is scarce."

The Prairie Chicken, the Red-winged Blackbird, and other birds have been reported as feeding upon the Chinch Bug, and Professor Forbes mentions the fact that one Cat-bird, three Brown Thrushes, and one Meadow-lark were found in 1880 to have eaten these insects "in barely sufficient number to show that the birds have no unconquerable prejudice against them. A single house-wren, shot in 1882, had also eaten a few Chinch Bugs." Dr. Thomas states that the common Frog, according to Professor Ross and others, consumes a large number of the bugs. "Professor Ross goes so far as to express the belief that the destruction of these animals by draining their natural haunts is one reason why the Chinch Bug is enabled to multiply as it does in some seasons."

No account of an injurious insect is complete without an enumeration of its natural enemies, and hence this summary has been given. It is plain, however, that the foes of the Chinch Bug are neither so numerous nor so active in its pursuit as are those of most of our other injurious insects. Almost the solitary exception seems, from the evidence, to be the common Quail, and on this account the following short table has been compiled. It illustrates the months in which the shooting of quails is allowed in the States in which the Chinch Bug becomes or may become injurious, and it shows that while these birds are in the main tolerably well protected, certain of the States which suffer most from the Chinch Bug might with profit follow the example of Colorado or Dakota and protect the Quail altogether for a series of years.

New York: Shooting of quails allowed from November 1 to January 1.

Maryland: Shooting of quails allowed from November 1 to December 24. There are, however, in this State, local county laws, some of which allow the shooting as early as October 1.

Virginia: Shooting of quails allowed west of the Blue Ridge October 15 to January 1, except in Rockbridge County, where it is allowed from October 15 to January 15; elsewhere October 15 to January 15.

Texas: Shooting of quails allowed from October 1 to April 1.

Georgia: Shooting of quails allowed from October 15 to April 1.

Wisconsin: Shooting of quails allowed from September 1 to December 1. Trapping prohibited.

Michigan: Shooting of quails allowed from November 1 to January 1. No trapping or snaring allowed for market.

Pennsylvania: Shooting of quails allowed from October 15 to January 1.

Tennessee: Shooting of quails allowed from October 1 to April 1 in Rutherford, Shelby, Tipton, and Fayette Counties; September 1 to February 1 in Robertson, Davidson, Lincoln, and Maury Counties; September 15 to March 1 in Montgomery and Cheatham Counties.

Missouri: Shooting of quails allowed from October 15 to February 1. Trapping prohibited except by owner of premises.

Delaware: Shooting of quails allowed from November 15 to January 1.

North Carolina: Shooting of quails allowed from October 15 to April 1, except in counties of Clay, Cherokee, Graham, Henderson, Jackson, Macon, Transylvania, Tyrrell, Johnston, Jones, Ware, Onslow, Carteret, and Columbus, in which they are not protected; in Currituck County, December 1 to April 1.

Iowa: Shooting of quails allowed from October 1 to January 1; no more than twenty-five quails to be killed in any one day by any one person.

Dakota: Quails protected absolutely to 1890.

Illinois: Shooting of quails allowed from November 1 to January 1. Snaring and trapping forbidden.

Ohio: Shooting of quails allowed from November 10 to January 1. Snaring and trapping forbidden. In Fulton County quails protected to November 1, 1890.

Nebraska: Shooting of quails allowed from October 1 to January 1. Snaring and trapping forbidden.

Indiana: Shooting of quails allowed from October 15 to December 20.

Minnesota: Shooting of quails allowed from September 1 to December 1. Trapping prohibited.

District of Columbia: Shooting of quails allowed from November 1 to February 1. Trapping prohibited.

South Carolina: Shooting of quails allowed from October 1 to March 15.

Montana: Shooting of quails allowed from August 15 to November 15.

Arkansas: Shooting of quails allowed from October 1 to March 1.

Colorado: Quails protected at all times.

West Virginia: Shooting of quails allowed from October 15 to January 1. Snaring prohibited.

Kentucky: Shooting of quails allowed from October 15 to February 1.

Idaho: Quails protected until September 1, 1887. (Present status of law unkown.)

New Mexico: Shooting of quails allowed from September 1 to May 1.

Kansas: Shooting of quails allowed from November 1 to January 1.

This compilation is drawn up in the main from an extended abstract of the State game laws, published in the American Field for August 20, 1887, Vol. XXVIII, No. 8.

DISEASES.—The Chinch Bug has long been known to be subject to a so-called bacterial disease, which occasionally kills it off. Dr. Shimer, in his long article in the Proceedings of the Academy of Natural Sciences of Philadelphia, gives the following account of his observations upon this disease in 1865 (Proceedings of the Academy of Natural Sciences of Philadelphia for 1867):

> *July* 16.—A farmer 4 miles from here informed me that a black coleopterous insect was destroying the Chinch-bugs on his farm very rapidly; and although I found his supposition to be an error, yet I found many dying on the low creek-bottom land from the effects of some disease, while they are yet in the larvæ state—a remarkable and rare phenomenon for insects thus in such a wholesale manner to be dying without attaining their maturity—and no insect enemy or other efficient cause to be observed capable of producing this important result.
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> On the low ground the young Chinch-bugs are all dead from the disease above alluded to, and the same disease is spreading rapidly on the hills and high prairies.

The weather has been very wet since the 1st of July, and the barley above alluded to, which I plowed beneath the ground, did not die, but assumed a yellow, sickly appearance; in its shady, compressed, unnatural position, the ends of the heads project from beneath the furrows. The Chinch-bugs also remained alive for a time, but feeding on the sickly grain and shaded from the sunlight, what little we had were attacked by disease in the same manner and about the same time as those on the low creek-bottom lands, meeting very rapidly the same fate, so that very few of them ever found their way to the neighboring corn.

July 28.—In the fields where sixty days ago I saw plenty of eggs, and forty-two days ago an abundance of young Chinch-bugs, the imago are beginning to develop quite plentifully. Great numbers in all stages of their development are dying of the prevailing disease.

August 8.—The majority of the Chinch-bugs yet alive are in the imago state, but they are being rapidly destroyed by the prevailing epidemic disease—more fatal to them than the plague of Asiatic cholera ever was to man; more fatal than any recorded disease among men or animals since time began. Scarcely one in a thousand of the vast hosts of young bugs observed at the middle of June yet remain alive, but plenty of dead ones may be seen everywhere, lying on the ground, covered with the common mold of decomposing animal matter and nothing else, even when examined by the microscope. Even of those that migrated to corn-fields a few weeks ago in such numbers as to cover the lower half of the corn-stalks, very few are to be found remaining alive; but the ground around the base of the corn-stalks every few days is to be found literally covered with their moldering, decomposing dead bodies. This is a matter so common as to be observed and often spoken of by farmers. They are dead everywhere; not lying on the ground alone, but sticking to the blades and stalks of corn in great numbers, in all stages of their development—larva, pupa, and imago

August 22.—It is almost impossible to find even a few cabinet specimens of Chinch-bugs alive, so that I am quite sorry that I did not secure a large supply of specimens while they were so numerous in former years; for it really appears quite probable that even cabinet specimens will be hard to secure, whereby to remember the fallen race of the unnumbered millions of former years.

September 13.—After a whole day's searching in the corn-fields I have just been able to find two larvæ and a few imago Chinch-bugs, against the great numbers above alluded to in the corn about this time last year.

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It is generally believed among entomologists that insect enemies are the most efficient means in nature for exterminating noxious insects; but in this remarkable fact in the history of insects the great epidemic of 1865 (there can be no doubt about this being an epidemic disease, because the insects died without attaining their maturity) we find a greater enemy, the greatest insect enemy ever recorded, a dreadful "plague," that in a few days almost utterly annihilated a race of beings living in the northern part of the valley of the Mississippi, outnumbering all the human beings that have ever lived on this planet since the morning of creation.

This disease among the Chinch-bugs was associated with the long-continued wet, cloudy, cold weather that prevailed during a greater portion of the period of their development, and doubtless was in a measure produced by deficient light, heat, and electricity, combined with excessive humidity of the atmosphere, whereby an imperfect physical ("bug") organization was developed. The disease was at its maximum during the moist weather that followed the cold rains of June and the first part of July. The young Chinch-bug spent a great portion of its time on or near the ground, where its body was colder than the atmosphere, hence upon philosophical principles there must have been an excessive precipitation of watery vapor in the bronchial tubes. These are the facts in the case, but in the midst of the great obscurity that envelops epidemic diseases among men, it would be only idle speculation to attempt to define the cause more definitely than the physiological laws already observed seem to indicate. At all events it will require many years of warm, dry summers, and accompanying winters of plenty of snow for protection, to re-instate the lost innumerable armies of this insect.

During the summer of 1866 the Chinch-bugs were very scarce in all the early spring, and up to near the harvest I was not able, with the most diligent search, to find one. At harvest I did succeed in finding a few in some localities.

Professor Forbes took up the study of the Chinch-bug disease in August, 1882, and has published several interesting accounts of his results. A short summary was published in his first report as State

Entomologist of Illinois for the year 1882 of the long account of his studies and experiments, and it is in such shape that we reproduce it here:

On the other hand, a much more important rôle is apparently played by certain obscure parasites not previously detected. One of these is a minute bacterium (*Micrococcus insectorum*, Burrill) infesting the alimentary canal, closely allied to the *Micrococcus* found in the stomach and intestines of Silk-worms, and now known to cause some of the destructive diseases of that insect. From the fact that these parasites were extremely abundant in specimens from a field where the bugs were rapidly dying, while in those from adjacent fields there were relatively very few, it was considered probable that they were related to this destruction of the bugs. This conclusion was supported by the fact that they were more abundant in old bugs than in young, while the mortality referred to evidently also chiefly affected the older individuals. It was found easy to cultivate the bacterium artificially in organic infusions, but no opportunity offered to apply it to healthy insects. Until this experiment is made and the effects carefully studied, it must remain possible that the coincidence noted was merely accidental and of no particular significance.

Another parasite discovered is similar to that well known as a common enemy of the house-fly, and belongs to the same genus (*Entomophthora.*) This attacks both old and young Chinch-bugs, and finally imbeds their bodies in a mass of mold. There is some reason to believe that this was the active agent in an immense destruction of Chinch-bugs which occurred in Northern Illinois in 1866, as described by Dr. Shimer, of Mount Carroll. Evidence is adduced of the possibility of artificially cultivating this parasite also, and applying it to the destruction of insects.

Since the publication of this report Professor Forbes has taken up the study of bacterial diseases of certain other insects, but there has been, so far as we are aware, no practical outcome as yet. The subject, however, has a rather hopeful look, although we should be inclined to expect more from the *Micrococcus* than from the *Entomophthora.* The evidence mentioned as to the possibility of artificially cultivating the latter is chiefly a translation of a paper by Metschnikoff in the Zoölogischer Anzeiger for 1880, pp. 44-47, in which it is shown that the Russian naturalist successfully induced the growth of the fungus, *Isaria destructor*, which had destroyed the celebrated *Anisoplia austriaca*, a grain pest in Russia, in beer mash. Successful attempts were made to infest healthy larvæ with green spores taken from diseased larvæ found in the fields, but no mention is made of success or even of experiment with the only practical substance, the beer-mash culture.

Professor Riley has always doubted the possibility of any practical success in this direction, and has pointed out the difficulties in the way. (See American Naturalist, November, 1883, p. 1170.)

In the introduction of the Fourth Report of the U. S. Entomological Commission (LXXXV) he makes use of the following language:

In treating of the use of yeast ferment or other fungus germs we have used essentially the language of the first edition. Time has only served to confirm us in our opinion of their practical futility in the field. The question of the practical use of these micro-organisms—these disease germs—as insecticides is a very fascinating one, and is much written about just now; but unfortunately it proves most alluring to those who have had the least practical experience in coping with injurious insects in the field, and is much more apt to assume importance to the closet theorists than to those who, from experience, are conscious of the difficulties involved in its applicability.

It will be appropos to quote Professor Forbes' latest utterance upon this point. He says:

Finally, *the artificial cultivation of the germs of the contagious diseases* of the chinch bug, with a view to spreading these diseases at will by means of such artificial culture. This is a theoretical remedy only, and much additional study and experiment will be required to put it on a practical basis.

WET WEATHER AND THE CHINCH BUG.

The great preponderance of evidence favors the idea, now considered well established, that wet weather is inimical to this insect. Dozens, we may almost say hundreds, of instances are on record in which the Chinch Bugs, after successfully hibernating in great numbers, have been rendered harmless by a wet spring, and in which, having laid their eggs and appeared again as the spring brood with greatly increased forces, a spell of rainy weather in early summer has caused them to vanish. Hence it follows that dry seasons favor the increase of the pest, and careful observation convinced Riley and others that after a season of moderate abundance (presumably, therefore, not a wet season) the occurrence of the bugs in destructive numbers the next season depends almost entirely upon the wetness or dryness of the ensuing spring.

The exact method in which wet weather accomplishes the destruction of the insect is a somewhat disputed point. That it is not actual submergence was pointed out by Professor Riley in his Second Missouri Report, and still further proven by an observation made by Hon. William McAdams and reported by Professor Forbes in his first report as Entomologist of Illinois, and which is sufficiently interesting to quote: "In his vicinity, in Jersey County [Ill.], they [the Chinch-bugs] were extremely abundant in the grain early in the spring, but were all apparently swept out of the country by a long and violent storm. Some days afterwards, when the water had subsided, he noticed in pulling over the drift-wood in the river bottoms immense numbers of Chinch-bugs among the rubbish, most of them still alive and crawling about."

Professor Forbes also concludes that simple exposure to moisture hardly has the effect attributed to rain, from experiments which he made as follows: "A number of hills infested by the bugs were successfully transplanted to boxes and variously treated with water for ten days. Some selected examples were thoroughly drenched every day, both ground and stalks; in other boxes only the ground was watered; in still others the corn was sprinkled every day, but the ground protected, and the remainder were left with only sufficient attention to keep the corn alive. During the time for which these experiments were continued no appreciable effect whatever was produced upon the bugs infesting the stalks. Those where the corn was watered were washed down upon the ground each time, but soon dried off and climbed up the stalk. At the end of this time the bugs under observation all commenced to disappear indiscriminately, without reference to the mode in which the corn had been treated, and the experiment was thus abruptly closed. Enough was learned, however, to show that a succession of heavy daily showers for more than a week would have no appreciable effect upon these insects in that stage. The weather was warm and pleasant, and the condition under which the experiments were carried on made it impossible to saturate the air."

So general a conclusion, it seems to us, is hardly warrantable from the conditions under which the experiments were made. If "the weather was warm and pleasant, and the condition under which the experiments were carried on made it impossible to saturate the air," the effect could hardly help but differ from that of a heavy shower in a corn-field, particularly from that of "a succession of heavy daily

showers for more than a week," when there would be considerable cloudy weather and the atmosphere on the whole would be moist.

Professor Riley has mentioned the fact that the larvæ and pupæ are more readily killed by the wet weather than the adult insects, but that the latter are also killed.

Mr. Walsh (Am. Ent., I, 175, 1869) gives the emphasis of italics to the following sentence: "In a hot, dry season Chinch-bugs are always the worst; in a wet season it is impossible for them to do any considerable amount of damage." Dr. Shimer (*loc. cit.*) in his account of the epidemic argued that it was doubtless the indirect effect of the wet weather. Dr. Thomas (Bull. 5, U. S. E. C.) expressed the opinion that the wet weather gave rise to a minute fungus which is the direct cause of the death of the insect.

Professor Forbes says: "The phenomena connected with the action of parasites which I have above described were apparently independent of any appreciable general cause, as they were most manifest at a time when the weather had been warm, dry, and altogether unexceptionable for from one to two months. It is not unlikely, however, that wet weather may have the effect to stimulate the development of this parasite, either directly or indirectly—a hypothesis which will reconcile all the facts now known, as well as the conflicting explanations of them which have been hitherto put forth."

Assuming the dry weather abundance and wet weather scarcity of the Chinch Bug to be proven, Dr. Thomas in 1880 published an elaborate article in which, by a comparison of the rain-fall for forty years with the destructive appearance of the insect for the same period, he not only established a definite relation between them, but upon an admittedly somewhat uncertain septenary periodicity of rainfall advanced the following practical conclusions:

The first and very important practical fact revealed is that we may expect at most but two Chinch-bug years in every seven, with the strong probability, amounting almost to a certainty, that there will not be two in succession. As heretofore stated, two successive dry years are necessary in order to develop this species in excessive numbers; the rain-fall records seldom show three dry years in succession, hence the Chinch-bugs are not likely to appear in injurious numbers in two successive years. The years 1854 and 1855 may, perhaps, form an exception to this rule. It is possible that the second brood of the first year may be sufficient to excite alarm, but experience has shown that they do but little injury. We may, perhaps, with safety assume as a general rule, subject to occasional exceptions, that they will not appear more than once in excessive numbers during any of the septenary periods.

If the facts shown in reference to periodicity in our rain-fall are confirmed by future investigations, and this periodicity shown to be a meteorological law of the area indicated, the practical advantage of this knowledge to our farmers is apparent to every one. By this knowledge they will be enabled to predict with a reasonable degree of certainty when to expect these insects, and can rotate their crops so as to suffer the least possible injury. This knowledge will also enable them to dispense with precautionary measures, except in such years as are likely to be followed by the appearance of the bugs.

Experience has shown, and farmers are now becoming fully aware of the fact, that spring wheat and corn are the crops that chiefly aid in sustaining and developing this pest. Why corn should aid in this respect is easily seen, as it is the only extensive crop on which the second brood can feed. But why spring wheat should aid more in developing them than winter wheat is not so easily explained, but that such is the fact must be admitted. It may possibly be accounted for on the presumption that the climate of the spring-wheat region is more congenial to them than that of the winter-wheat area.

These facts, combined with a knowledge of the time when the dry seasons are to be expected, will enable the farmers to substitute other crops as far as possible in place of spring wheat and corn. Even if the conclusion in reference to periodicity in rain-fall should prove erroneous, the fact that two successive dry years are necessary to develop this species in excessive numbers will suffice to give notice at least

one season in advance and allow the farmers to adapt their crops to the circumstances. When a dry season comes, and an examination shows that the bugs are on the increase, winter wheat, wherever it is possible to do so, should be substituted for spring wheat, and oats, as far as possible, for corn.

The uncertainty in reference to temperature will, perhaps, always prevent us from predicting with certainty that a coming year will be marked by the appearance of these insects, but we may say with assurance that a wet year will not be followed by a Chinch-bug year. Although this is not all we desire to know in this respect, it is nevertheless a very important fact and may be used to manifest advantage by our agriculturists.

It is proper to remark at this point that we have been speaking only of the rain-fall over the whole area designated and the general appearance of the Chinch-bug over the same area.

That these insects have appeared even in injurious numbers in limited localities in intermediate years, or times different from those indicated as possible Chinch-bug years, is certainly true. But if the theory advanced is correct when applied to the area designated as a whole, it will probably prove true when applied to more limited localities. That is to say, if the meteorological record of a given locality within this area for a long series of years is examined, it will probably reveal the fact that there is a similar periodicity in the rain-fall, though possibly not septenary. If this is found to be true, then the farmers of that locality will have a guide by which to rotate their crops and to take precautionary measures.

It therefore becomes important for each section to keep a record, at least of the rain-fall; for this will be of advantage, not only in counteracting the Chinch-bugs but numerous other species, and if the periodicity is ascertained, will enable the farmers to adapt their crops as far as possible to the wet or dry seasons.

In the October (1880) number of the American Entomologist (Vol. III), Dr. Thomas published practically the same article as that above quoted and stated that the bugs would probably appear over the region indicated in 1881. He advised in consequence the sowing of large areas of oats in 1881. Professor Riley, in his Annual Report for 1881–'82, page 87, mentioned this prediction and advice and showed that the prediction was fulfilled in part at least by the occurrence of the bugs in destructive numbers in several Western States. With regard to the adoption of Dr. Thomas' advice, however, he pointed out the rather curious fact that Dr. Thomas' own State (Illinois) was the only one of the large oat-producing States in which the acreage of this crop was not increased, but was somewhat diminished. Dr. Thomas, in the letter of transmittal to his report for 1881, announced the fulfillment of his prediction and predicted immunity for 1882. Professor Riley (*loc. cit.*) showed that in spite of frequent rains in the spring of 1882, and in spite of the fact that 1881 was a Chinch-bug year, the bugs appeared in great numbers in parts of Illinois, Kansas, and Missouri in April and May, but that by June the reports were less alarming. The year as a whole was not marked by any extensive damage.

Upon Dr. Thomas' theory the year 1888 should not be a Chinch-bug year, and, while not desiring to encroach upon his prerogative as a seer, we are inclined to hold the same opinion concerning this season at least.

Curiously enough, an anonymous writer (J. C. H. S., of Sedgwick County, Kans.) in the Prairie Farmer for June 10, 1882, commenting upon and criticising Dr. Thomas' theory, himself predicts that 1887 would be a year of drought and consequently a Chinch-bug year, a much more daring prediction than Dr. Thomas cared to make and which has yet been perfectly fulfilled. According to this writer's somewhat arbitrary system 1894 should again bring a severe drought.

We introduce here, as bearing upon the rain-fall influence in the interesting North Carolina locality, the following table of temperature and rain-fall at Chapel Hill, compiled by Professor Atkinson.

It will be noticed that while the total rain-fall in both 1886 and 1887 was greater than in 1885, that during September, October, and November, 1886, and March and April, 1887, was comparatively slight, and that during June and July, 1887, high temperature occurred with the comparatively heavy rain-fall.

Table of temperature and rain-fall for spring, summer, and autumn, at Chapel Hill, N. C., for the years 1885, 1886. *and* 1887.

[The temperature is expressed in degrees Fahrenheit.]	March.	April.	May.	June.	July.	August.	September.	October.	November.	Totals to October.
1885.										
Highest temperature	75	94	90	94	100	94	92	81	71	......
Lowest temperature	15	31	40	63	61	57	46	35	27	......
Mean temperature	42.3	55.3	66.5	74.7	77.3	74.8	68	56.6	52.3	......
Rain-fall (inches)	3.5	2.71	4.34	1.32	3.95	1.98	6.45	6.27	3.81	24.25
1886.										
Highest temperature	80	93	93	93	98.5	96	94	89	77	......
Lowest temperature	24	33	46	53	62	55	52	35	24	......
Mean temperature	49.3	59.6	67.7	78.8	76.9	75.9	75.9	58.6	49.1	.....
Rain-fall (inches)	4.97	5.99	4	6.22	7.48	9.91	2.86	1.47	2.79	41.43
1887.										
Highest temperature	83	91	93	101.8	103	92	98	....	....	......
Lowest temperature	26	28	45	49.7	65.7	52	36	....	....	......
Mean temperature	46.9	58.3	70.6	74.7	79.8	74.4	69	....	....	......
Rain-fall (inches)	3.93	2.56	6.59	6.22	6.11	10.8	1.39	....	....	37.60

The following tables are published for comparative purposes. They are kindly furnished by the Chief Signal Officer, and include the official records of precipitation in Chinch Bug States for 1885, 1886, 1887:

Stations.	1885.	1886.	1887.
	Inches.	*Inches.*	*Inches.*
Maryland:			
Baltimore	46.04	52.11	43.59
Virginia:			
Cape Henry	36.55	[1]44.76	....
Chincoteague	41.85	45.23	[2]19.74
Lynchburgh	46.35	51.85	40.62
Norfolk	43.25	54.33	47.72
North Carolina:			
Charlotte	58.35	64.60	51.26
Hatteras	68.02	54.72	55.07
Kitty Hawk	54.78	[1]53.98	....
Macon, Fort	62.34	[1]47.50	....
Smithville (now Southport)	48.07	38.93	59.49
Wilmington	60.42	56.43	51.47
Indiana:			
Greencastle	50.11	[3]31.65	....
Indianapolis	39.51	39.88	33.08
Ohio:			
Cincinnati	33.94	31.35	35.08
Cleveland	39.93	37.34	35.36
Columbus	42.25	42.39	30.25
Sandusky	34.23	31.00	29.85
Toledo	33.19	32.90	32.01

[1]Closed December 31, 1886.
[2]Closed June 18, 1887.
[3]Closed November 4, 1886.

Stations.	1885.	1886.	Part 1887.
	Inches.	*Inches.*	*Inches.*
Illinois:			
Cairo	31.99	37.98	26.75
Chicago	44.37	26.77	29.13
Springfield	38.61	31.69	25.15
Wisconsin:			
La Crosse	30.70	22.49	17.37
Milwaukee	32.58	31.46	30.46
Minnesota:			
Duluth	19.96	33.37	28.56
Moorehead	22.68	26.76	21.97
Saint Paul	25.33	22.89	25.85
Saint Vincent	16.58	15.04	18.47
Missouri:			
Lamar	[1]47.05	33.48	35.72
Saint Louis	45.59	44.34	35.30
Kansas:			
Concordia	[2]17.11	28.24	25.26
Dodge City	23.71	19.35	15.80
Leavenworth	43.64	22.25	37.05

[1] Ten months' record. [2] Eight months' record.

REMEDIES AND PREVENTIVES.

The remedies and preventives recommended as late as the publication of Professor Riley's Seventh Rept. Ins. Mo., and there considered by him, are as follows: Irrigation, burning, trapping, trampling, rolling, manuring, early sowing, mixing seed or protecting one plant by another, preventing the migration from one field to another by upright boards or by plowed furrows or ditches, abstaining from cultivation of grains upon which the insect feeds. These remedies were also treated in detail by Dr. Thomas in Bulletin 5 of the Commission. Since this although many changes have been rung in the agricultural newspapers on these remedies, very few entirely new ideas have been advanced. We may mention more particularly, before taking up a more detailed consideration of this question, the successful adoption of the kerosene emulsion for application at the time of migration or immediately afterwards.

PREVENTIONS.—*Clean Cultivation.*—With no insect more than the Chinch Bug is there greater necessity for clean cultivation. We have shown already that the insect hibernates under rubbish of all kinds, and that the grass and weeds growing in the fence corners and the leaves which accumulate there are admirable places for these insects to collect and winter. Where corn-stalks are left in the fields, and where rubbish of any kind is allowed to accumulate, there the bugs will surely be found. Therefore the more thoroughly a field is cleaned up in the fall, the more carefully the fence corners are weeded out, and the more the bare soil is turned under, the fewer will be the chances for successful hibernation.

Diversified Farming.—It follows from what we have said concerning food-plants of this insect and the crops most attacked that, from the Chinch-bug standpoint alone, to say nothing of its other advantages, the more diversified the system of crops the better chance there will be for preventing it. A farmer who plants only Winter Wheat, Corn, and small vegetable patches, as is the practice in so many parts of the West, will always be liable to lose a large share, if not all, of his expected remuneration from the attacks of this insect. "Diversified farming with wheat mainly left out" is the editorial recommendation of the Prairie Farmer (September 17, 1887), and is certainly an exemplification of condensed wisdom.

The object of the omission of Wheat, particularly Winter Wheat, is of course to afford as little food as possible for the first generation. Similarly the plan has been suggested of abstaining from Corn in wheat and other small grain-growing regions, with the purpose of affording as little food as possible for the *second* brood. The result of this plan will be that after harvest the bugs will make their way to the wild grasses, will disperse more, and vastly fewer will successfully hibernate than if there were the usual superabundant supply of food for the second generation.

Rotation of Crops.—From these same facts it also follows, with self-evident clearness, that crops attractive to these insects should not be sown year after year upon the same ground. This idea is so plain as to require no elaboration. Abstaining from the cultivation of grain upon which the insect feeds where, in spite of the efforts for protection elsewhere mentioned, the Chinch-bug damage is still great, will of course end the difficulty. Wheat, Barley, Rye, Hungarian grass, and Millet are all important crops, but there are others, such as Buckwheat, Clover, Flax, Hemp, all vegetables, and fruits which could well be made to take their place for a year or two or more if it should become necessary. The one great result of the Chinch-bug convention held in Kansas in 1881 was the adoption of a resolution to abstain from the cultivation of Wheat from the growing crops, the length of time not being mentioned. As we have previously shown, large areas of oats could be successfully grown, but in corn-growing regions most small grains must be left alone, and, above all, Winter Wheat and Barley. Even without concert of action among the farmers of a certain region, it will benefit the individual to abstain from wheat and to grow oats in preference in a year when bugs are expected; but concert of action is far preferable.

Early Sowing and Manuring.—From the evident fact that a strong, healthy, well-grown plant will better resist the attacks of the insect the deduction follows that Winter Wheat sown early, upon well-manured ground and given careful cultivation will be farther advanced in the spring and will suffer less from the attacks of the bug. Heavy manuring will also cause a denser growth, which experience shows to be prejudicial to the bugs.

Rolling.—The female Chinch Bug in the spring seeks preferably friable ground in which to lay her eggs, consequently rolling the land in the fall after the crop of winter wheat is put in will render it less favorable to such egg-laying. The same thing may be done with even better success after sowing Spring Wheat.

Sowing an unattractive Crop with Wheat.—Good results have been obtained, as shown by Professor Riley, by sowing one or two quarts of Flax to the acre in the spring among Fall Wheat. It is put in in early spring with a light harrowing and rolling. Its growth does not materially injure the crop. Flax and Barley have also been sown mixed upon the same ground, the seed being separated in cleaning. Similarly corn-fields which promised a poor stand have been harrowed and sown to Buckwheat. We have already mentioned in our section on food-plants the successful experiment detailed by Professor Forbes in sowing Timothy in the fall with Winter Wheat or Rye, and the same author states that in southern Illinois the sowing of Clover in spring on Winter Wheat is largely practiced, "with unquestionably good effect, provided that the clover grows freely enough to shade the ground by the time the young Chinch-bug gets fairly under way." In

that latitude, however, he states that the Clover often makes too slow a start to effect this purpose. Professor Riley also states that it is recommended to sow one bushel of Winter Rye with each twelve bushels of Spring Wheat, either for the same reason or from the idea that the bugs will prefer the younger to the older grain.

DIRECT WINTER REMEDIES.—Stress should be laid upon the great necessity for concerted work in winter time.

Burning.—Professor Riley says: "I can not lay too much stress on the importance of winter work in burning corn-stalks, old boards, and all kinds of grass, weeds, rubbish, and litter around grain-fields, and even the leaves in the adjoining woods, in and under all of which the little pest hibernates."

In almost every locality the insects will be found to have some particularly favored hibernating place, where they can be attacked and burned out. The locality studied by Professor Atkinson in North Carolina and mentioned in a previous paragraph is a particularly good instance. There a little careful search in the fall showed the bugs preparing to hibernate in great numbers in the Crab-grass, and nothing could be easier in the winter than to burn down every spear of this grass in the vicinity of the grain-fields. In the newer parts of the West, where unbroken prairie land adjoins fields of grain it is advisable to burn over the former early every spring. Indeed, this course is an absolute necessity under such conditions.

Fall Plowing and Harrowing.—After burning, if the soil can be plowed and harrowed, the chances for successful hibernation of the bugs which escape burning will be reduced to a minimum. In the same way, without burning, late fall plowing and harrowing will do much good.

Gas Lime.—Where gas lime can be easily and cheaply obtained, an application of 200 bushels to the acre will prove valuable as a fertilizer, and will destroy such hibernating insects as it may reach.

Trapping.—We quote again from Professor Riley: "Much good winter work may be done also in the way of trapping the bugs. In seeking winter quarters they show a decided partiality for any flat substance, such as old boards that do not rest too closely upon the ground. If all old boards that can be obtained are laid around the field in the fall in such manner that the larger part of the lower surface will not quite rest on the ground, which of course it will not do if the ground is in the least uneven or covered with grass, the bugs will collect under such traps, and during the cold weather of winter may be scraped from them onto dry straw and burned." He has also suggested that shocks of the corn-stalks should be made at intervals throughout the field before winter sets in, so as to attract the bugs which will congregate in the shocks, where they can be burned at leisure. Almost any inflammable rubbish could be used for this purpose. In the neighborhood of sorghum-mills bagasse has been used with good effect. The piles should not be too large or too compact. They should be placed during September and should be burned in December.

Trampling.—The following passage is from Professor Riley: "Where the custom of allowing cattle to range during the winter in the husked corn-fields prevails, even the few Chinch Bugs which secrete in the stalks are apt to get killed by the feeding and trampling."

DIRECT SUMMER REMEDIES BEFORE MIGRATION.—As is the case with so many other destructive insects, it is not until they are under full headway and in the act of doing their greatest damage that an

appeal is made to the entomologist for relief, and at such times it is usually by far the most difficult thing to give any advice. A wheat-field full of Chinch Bugs is as disagreeable a sight to the economic entomologist as it is to the farmer who owns it, for nothing can be done to save it. If the hand of Providence should interpose with a long-continued drenching rain, relief would be gained, but in almost no other way can the crops be saved.

Irrigation.—It was the fact just mentioned which led Professor Riley, in his Seventh Rept. Ins. Mo., to strongly recommend irrigation where it can be practiced. He says: "Irrigation, where it can be applied—and it can be in much of the territory in the vicinity of the Rocky Mountains, where the insect commits sad havoc, and with a little effort in many regions in the heart of the Mississippi Valley—is the only really available, practicable remedy after the bugs have commenced multiplying in the spring. I wish to lay particular stress on this matter of irrigation, believing as I do, that it is an effectual antidote against this pest, and that by overflowing a grain-field for a couple of days, or by saturating the ground for as many more in the month of May, we may effectually prevent its subsequent injuries. * * * We can not, at the critical moment, expect much aid from its natural enemies, for these are few, and attack it mostly in the winter time. We must, therefore, in our warfare with this pest, depend mainly on preventive measures where irrigation is impossible."

Later (Amer. Agriculturist, Dec., 1881, also Ann. Rept. as Entomologist, Dept. Agr., for 1881–'82, pp. 88, 89) he expressed himself even more explicitly upon this subject:

"I have found no occasion to change my opinion as to the value and potency of irrigation as a remedy for Chinch-bug injuries, a remedy, too, that is within the reach of most farmers; for there are few who might not, with the aid of proper windmills, obtain the water requisite for irrigating their fields at the needed time, while many have natural irrigating facilities. I have repeatedly laid stress in my writings on the importance of irrigation in combatting several of our worst insect enemies, and, aside from its benefits in this direction, every recurrence of a droughty year, such as the present, in large portions of the United States, convinces me of its importance as a means of guarding against failure of crops from excessive drought. I am glad to know that many farmers, and especially small fruit-growers in the vicinity of New York, are preparing in one way or another for irrigation whenever it becomes necessary, and I was pleased to hear Dr. Hexamer, at the late meeting of the American Pomological Society, urge a general system of irrigation as the most profitable investment the cultivator can make in a climate subject to such periods of drought as ours is known to be."

Burning.—In addition to winter burning the remedy can be used to good effect in other cases. For instance, where the attack of the bugs appears to be confined to a definite portion of the field, that portion should be overlaid with straw and burned, if not too large. Another pertinent suggestion is made by Dr. Thomas in Bulletin 5, U. S. E. C., and this has the indorsement of practical use by certain Illinois farmers. "If it is found at the time wheat is harvested that the bugs have not taken their departure, as is the case in the winter-wheat section, this fact may be taken advantage of to destroy a very large portion of them. If the wheat is at once threshed and the straw scattered over the stubble and burned, it will destroy all or most of those that

are there. I know of one section in southern Illinois where this has been practiced for a number of years by the German farmers, with good results." This remedy is very practical and doubtless can be used to good effect under such circumstances.

The following experiments in burning were made the past season at Ames, Iowa, by Professor Osborn, and the account is taken from his manuscript report:

On July 16 the stubble adjoining a corn-field was observed to contain large numbers of bugs traveling toward Corn. In the afternoon this migration was going on quite actively, and as the stubble was now quite dry it was fired with a view of destroying bugs remaining in it. Where tolerably thick, and when there was a fair breeze, it burned readily, but it was necessary to take some pains in carrying the flame along past thin spots to keep it from dying out. A considerable portion of the field, however, was successfully burned over, and the dead bodies of many bugs not completely consumed, which could easily be found on examining the burnt area, testified to the destruction of hosts of the pests. The bugs thus killed were mostly young larvæ, the majority of the adults and larger larvæ and the pupæ having already moved out. The number destroyed, however, must, I think, have well repaid the little trouble necessary to burn the stubble.

Early in August the bugs had so multiplied in a field of Hungarian grass that no further growth seemed probable, and most of the field was mown and the hay secured. A narrow strip, however, was left next the Corn, the plan being to burn this as soon as bugs began passing to the Corn. When the bugs started, however (August 13), the grass was not dry enough to burn except in spots. In such places as would burn, however, hosts of bugs were consumed. This strip was at once mown, and after drying a few hours another attempt made to burn it, as also on the following day; but portions were still too green to burn rapidly, and, unfortunately for the experiment, the two or three days following were not hot and dry enough to render it fit to burn readily. A few days later, however, on a dry day with a fair breeze, most of the strip remaining unburnt was burned over, and examination showed that great numbers of young bugs remaining were destroyed. Bugs, if under ground or secreted in roots of stubble, will not be killed; hence to destroy greatest numbers, as well as to secure most rapid burning, the fire should be started in the hottest part of a dry day, when bugs in greatest number will be moving.

PREVENTION OF MIGRATION—DIRECT REMEDIES DURING AND AFTER MIGRATION.—As has been so often pointed out, a great deal can be done in the way of destroying the insects at the time when they migrate from the wheat-fields, towards the close of the first generation, to Corn and other neighboring crops.

Ditching.—As long ago as LeBaron's first paper and as Fitch's second report, the method of digging a ditch or plowing a furrow around the infested field was in vogue. If a plowed furrow is made the perpendicular side should be towards the field to be protected and the furrow should be kept friable by dragging a log or brush occasionally through it, or, better still, a triangular weighted trough. The migrating bugs will fail to climb the side of the furrow and will fall back into it, where they can be covered with straw and burned. With care and activity the neighboring fields can be thus protected.

A modification of this plan appears in an unplaced newspaper cutting in our possession. It is as follows: "When they first appear, as they usually do, on the side of the corn-field, and before they have entered it, cut five or six rows of the corn and clear the ground; then plow a strip of land 8 or 10 feet wide, leaving a deep furrow in the center of the same. Then take the corn-stalks which were taken from the land and place them across the dead furrow and the trap is complete. When the bugs approach the field they will pass in under the corn placed across the dead furrow, and, preferring the shade and moisture, remain there until the stalks become perfectly dry,

when they can be put through a process of cremation that will prove effectual in destroying them. Should they first appear in the middle of a field of corn (as it not unfrequently happens they do), they can be surrounded on the foregoing plan and destroyed in the same way. This plan we consider the most practical of any that has come under our observation, and is corroborated to some extent by the experience of J. W. Martin, an observing farmer whose experiments are given in the Osage Mission (Kans.) Journal."

Tarred Boards or Tar alone.—The plan has been adopted and is recommended in the reports of Professor Riley and others of using common fence boards—6-inches wide and less—setting them upon edge and making a barrier of them around the infested fields, care being taken to cover the lower edge so that the bugs would not crawl under them. The upper edge is spread with fresh tar, which is occasionally renewed. Vast numbers are taken out from holes dug at intervals on the hitherside of the barrier in which the marching armies are collected. Commenting upon this remedy Professor Riley says: "With a little care to keep the tar moist by renewal, the boards may be dispensed with and the tar poured out of a kettle onto the ground. About a gallon is required to the rod, and it should be renewed every other day, oftener when rains prevail, until the bugs are destroyed." According to Dr. LeBaron this method was extensively used in the central part of Illinois, and especially in the vicinity of the Bloomington gas-works in 1872. He saw the operation performed near Bloomington where the tar was poured from an old tea-kettle on the ground along the exposed sides of a corn-field. This remedy, however, will seldom be used on account of its expense, except in such situations as that mentioned, where the tar can be readily and cheaply procured.

Sowing Strips of Plants distasteful to the Bugs around the Fields to be protected.—This remedy has been urged by certain authors and the crops to be used as barriers are preferably Flax, Hemp, Clover, or Buckwheat. The effect of this will be to deter and destroy the migrating individuals and cause the death of the young ones by starvation. It is, however, not a thorough remedy, and is not to be compared with the more direct remedies which cause the almost complete destruction of the insect.

Sowing Strips of favored Food around the Fields to be protected.—A strip of Timothy, Hungarian grass, or Millet may be sown around the corn-field to good advantage, with the object of entrapping the migrating bugs by plowing it under and burning the ground over when it has become filled with the migrating armies in transit. The bugs of the first generation which are full-grown will lay their eggs by preference in this protective strip, and these will be destroyed by the plowing and burning.

Hot Water and Soap-suds.—The application of strong soap-suds to the insects when gathered upon the outer rows of corn is recommended by a writer in the Southern Planter many years ago, and was also given by Dr. Fitch. Statement is made that a half gill or a gill poured upon each stalk will kill them all, and that the labor is not half so great as a single hoeing of the crop. Hot water has been recommended for a similar purpose by subsequent writers.

Kerosene emulsion.—A new and, under certain circumstances, very efficacious remedy for the Chinch Bug was introduced when Professor Riley, in 1882, first suggested to Professor Forbes the advisability of experimenting with this substance upon this insect. The results of

Professor Forbes' first experiments were published in Bulletin No. 2 of this Division (February, 1883), pages 23 to 25. The following solutions were used in these experiments:

"*Solutions with which dilutions were made.*—(1) Soap-suds, 1 pound soap to 10 gallons water; (2) soap-suds, 1 pound soap to 20 gallons water; (3) potash, 1 pound to 50 gallons water."

Emulsions as diluted.

	Per cent. of kerosene.
A. 2 parts kerosene, 1 part milk, 45 parts water	4
B. 1 part kerosene, 1 part milk, 18 parts water	5
C. 1 part kerosene, 1 part milk, 18 parts solution 1	5
D. 1 part kerosene, 1 part milk, 38 parts solution 2	2½
E. 1 part kerosene, 1 part milk, 38 parts water	2½
F. 1 part kerosene, 1 part milk, 38 parts solution 3	2½
G. 1 part kerosene, 1 part milk, 30 parts solution 2	3

All of these were efficacious. Fortunately, at the time when such application is to be made, viz, just after wheat harvest, help is abundant and the work can be done at a reasonable expense. Experiments made by Professor Forbes show that a simple mechanical mixture of 1 part of kerosene to 3 of water will kill the bugs and not injure half-grown corn, if it is kept constantly adjected. But the original soap emulsion, recommended so often in the reports of this Department, and made according to the formula originally proposed by Mr. Hubbard, will be much safer and will do thorough work. It will do no harm to repeat this formula:

Kerosene	2 gallons	= 67 per cent.
Common soap or whale-oil soap	½ pound	= 33 per cent.
Water	1 gallon	

Heat the solution of soap and add it boiling hot to the kerosene. Churn the mixture by means of a force-pump and spray-nozzle for five or ten minutes. The emulsion, if perfect, forms a cream which thickens on cooling, and should adhere without oiliness to the surface of glass. Dilute before using 1 part of the emulsion with 9 parts of cold water. The above formula gives 3 gallons of emulsion and makes, when diluted, 30 gallons of wash.

We realize the objections to recommending anything complicated in the way of a mixture and of apparatus for applying it, and in consequence we may state, as showing that an ingenious individual who is in earnest need not be hindered by lack of a proper apparatus for applying this mixture, the experience of Major R. S. Tucker, of Raleigh, N. C., as published in the News and Observer and in a special bulletin of the State department of agriculture, Raleigh, June 29, 1887. His letter stated, in brief, that, having tried a number of remedies, he learned of the kerosene emulsion at a time when the pest was most abundant upon the outer rows of corn; not having any force-pump or spray-nozzle with which to churn the emulsion he whipped the mixture in a large receptacle with a bunch of twigs for ten or fifteen minutes and then applied it to his outer rows of corn with a common water-sprinkler. The results were admirable, and certainly he deserved success for his trial.

Another practical test was made by Professor Atkinson, and reported upon in the bulletin just mentioned, as follows:

Mr. William F. Stroud, of Chapel Hill, had a field of Wheat which was infested with the Chinch Bugs. When the Wheat was harvested they immediately betook

themselves to the Corn, which was adjacent. Some of the corn-stalks for 1 foot or 18 inches above ground were literally black with the mass of insects, and sometimes when they could not be seen outside they were found in great numbers between the sheath of the blade and the stalk.

[Here follows the kerosene-soap emulsion formula just given.]

I found these proportions made the liquid a little weak, and I diluted in the proportion of six parts of cold water to one of the emulsion. The application of this to the Corn, June 25, was a perfect success in killing the bugs, and the Corn was examined later and was found to have sustained not the slightest injury.*

In my experiment I used a spraying apparatus, manufactured by A. H. Nixon, Dayton, Ohio, which consists of a square tank, which has a capacity of 8 gallons, with a force-pump hose and spray nozzel attached. This machine (called the Little Gem) was placed upon a rough sled made for the purpose, which was drawn between the rows by a mule.

As the spraying apparatus produced too wide a stream to apply the liquid rapidly and effectively to the stalks of Corn, I removed the spraying portion of the nozzle and used the part which produces a very narrow but strong stream (one-sixteenth of an inch in diameter). The liquid would run down the stalks and between the sheath of the blade and stalk, killing instantly the hundreds of insects with which it came in contact. The two rows were sprayed as far as the stream would reach on each side, and then the mule moved on to stop for another application. In this way the Corn was gone over very rapidly. Where a force-pump can be obtained it is better to apply it with this, but the nozzle should be very small, so as to throw a very narrow stream or spray directly against the stalk. If a force-pump can not be obtained, a common watering-pot, with a narrow nozzle, could be used very effectively. Several of these could be used, the operators going quite rapidly from one stalk or hill to another.

There is no reason why all should not get rid of the Chinch Bug on Corn, for a failure to kill the bugs would arise from some fault in the application, and the application can be made cheaper than a dressing of the Corn could be made with the hoe.

This application was made late in June, and Mr. Stroud reported several times later in the season that nothing more had been seen of the bugs, and Professor Atkinson, visiting the field October 17, found no Chinch Bugs in the corn-stalks where the emulsion was used, nor in the neighboring Crab-grass. Some were found, however, about 40 rods away in some late Corn, but they were few in number.

Professor Osborn's experiments with kerosene emulsions, made during the summer at our request at Ames, Iowa, are reported by him as follows:

A number of trials were made with kerosene emulsion first with a view to testing its value under various conditions, and afterward for the sake of checking the damage threatened to Corn.

The first trial was made July 15, the emulsion used being the common one, consisting of kerosene, soap, and water diluted to about 5 per cent. kerosene. The bugs were killed very quickly by this application, and great numbers of them could be reached, but many in particularly secreted places, in folds of leaves and under lumps of earth, escaped. Thrown on to the leaves and running down between leaf and stalk, it dislodged and killed immense numbers. Thrown against stalks where they were congregated it would quickly dislodge the mass, and while it was impossible to see whether all driven off in this way were sufficiently wet to kill them, it was certain that most of them were. This application was at the rate of about 1 gallon of emulsion or 12 gallons of the diluted mixture to 5 rows of Corn for 32 rods, or what would equal 5 gallons of emulsion, 60 gallons of diluted mixture to the acre, or a cost for material of less than 60 cents per acre. In trials of the emulsion diluted to range from 2 per cent. to 7 per cent. of kerosene, less than 4 or 5 per cent. was found to be unsatisfactory, and at the lowest figure bugs even when thoroughly drenched and kept for a time in the fluid were able to recover. A mixture (about 2 per cent., possibly a little less) which killed plant lice almost instantly, affected Chinch Bugs but slightly, if at all, and they afterward recovered and lived in confinement for many days.

*Professor Atkinson has since written that subsequent tests convinced him that one part of the emulsion to nine of water made the mixture quite strong enough.—L. O. H.

On August 15 applied kerosene emulsion to bugs accumulating on Corn, using an emulsion diluted to contain about 6 per cent. kerosene and spraying with cyclone nozzle. Great numbers of bugs could be found dead within a few minutes after application, and on the following day hosts of dead could be found on the ground around the hills treated. In places, however, the stalks had become well covered by live bugs that had moved in to fill the place of the slain.

Subsequently the farm department applied it on a larger scale, using 5 to 6 per cent. emulsion, and spraying from barrels in a wagon, one man working the force-pump and another manipulating the hose and cyclone nozzle, walking rapidly among the hills of Corn and directing the spray upon the masses of bugs. This resulted in the destruction of great numbers. In this application the cyclone nozzle was found by all means most satisfactory.

I suggested its trial to some of my correspondents, and one letter received in reply is of sufficient interest to be noted:

CAMBRIDGE, IOWA, *July* 20, 1887.

DEAR SIR: Your most satisfactory letter received some time since. The conclusion is a success; it was instant death to the Chinch Bugs. But it takes so much when you want to go over 5 or 6 acres that one can not stand the expense. It could be stood to go over it once or twice if I could have got the bugs all on the Corn, but they would a part stay on the Corn while the rest would lie under sods and anything else that would protect them from the sun. When your letter reached us they had left the Wheat (which they fully destroyed), and had gone into the Corn, which they killed for ten or twelve rows in some places, and some places not so far. Then they scattered over more territory for a time, but now they have left the Corn (almost), having flown away, I think. I am under obligations to you for your kindness.

Very respectfully,

J. E. WARREN.

Professor OSBORN,
Ames, Iowa.

The use of kerosene can hardly be expected to prove of value except when the bugs are massing on Corn. At this time, application to an acre or two of the field next to stubble may do much to save the rest of the field. By arranging nozzles with special reference to most efficient work in corn rows, and while Corn is small enough to drive a team in the field astride of one row, I think spraying can be done quite thoroughly at a cost of 30 to 40 cents per acre for material.

A cyclone nozzle, with pressure sufficient to do good work, discharges about 1 pint of liquid per minute. Adjusting three nozzles to play upon one row of Corn, one each side and one from above, and allowing teams to walk slowly 2 miles per hour, and it will take 30 gallons of liquid per acre, which, using 5 to 6 per cent. emulsion, costs about 30 cents, exclusive of labor, which for team and man an hour and a quarter would be about 40 cents more. First cost of force pump must, of course, be considered; the cost of labor on the farm, however, where the farmer uses his own team and does the managing of apparatus himself, might be counted less. By using only two nozzles or by driving faster the expense will be lessened.

BOGUS CHINCH BUGS.

Professor Riley figures and describes in his Seventh Missouri Report four species of Heteroptera which are frequently mistaken for the Chinch Bug and are often the cause of unnecessary alarm. We have reproduced the figures of these species upon Plate III. The first is the False Chinch Bug (*Nysius angustatus*, Uhl, fig. 9), which was frequently sent to Professor Riley. It is found all over the country, and occasionally damages certain crops quite seriously, Grape-vines, Strawberries, Potatoes, young Apple grafts, and all cruciferous plants. It is also very fond of Purslane, and, as mentioned elsewhere in this report, it is found in California congregating under *Polygonum*. It is the insect which caused the alarm in California in 1885. It was originally described by Mr. Uhler under the name given above, but was subsequently redescribed by Mr. William R. Howard as *Nysius raphani* and by Professor Riley as *Nysius destructor*, who cited Mr. Uhler's authority at the time for considering the form distinct.

The Insidious Flower-bug (*Triphleps insidiosus*, Say fig. 12) is another of these bogus Chinch Bugs. It is also a very wide-spread insect, and, so far from being injurious, it is one of the comparatively few insects which prey upon the Chinch Bug.

The Ash-gray Leaf-bug (*Piesma cinerea*, Say fig. 13) is another widespread species which occasionally damages grape blossoms in early spring, but lives principally upon forest trees and shrubs. This species is also often mistaken for our insect.

The Flea-like Negro-bug (*Corimelæna pulicaria*, Germ. fig. 14) is the fourth. Its appearance is more different from the Chinch Bug than any of the insects mentioned under this head, as is plainly shown by the figure. It feeds abundantly upon the fruit of the Raspberry and punctures also the stem of the Strawberry and the blossoms, leaves, and fruit-stems of the Cherry and Quince. It is also injurious to certain garden flowers and to certain weeds, among which Professor Riley mentions *Ceanothus americanus* and *Veronica peregrina*.

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This list is not intended to be a complete bibliography, but contains simply the titles of the more important articles, nearly all of which have been consulted in preparing this article.

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[Original description, from single specimen taken in Virginia.]

1837. NEW ENGLAND FARMER, XVI, p. 21.

[Prevalence of the "Chintz-bug" in Cumberland County, Va.]

1839. GIBBES, WILMOT S.—The season, crops, and insects in South Carolina. Cultivator, August, 1839, VI, 103, 104.

[Ravages of *Blissus leucopterus*.]

1845. PRAIRIE FARMER, V, 227.

[Injuries in Hancock County, Ill.]

PRAIRIE FARMER, V, 287. "Chinch-bugs."

[Injuries in Tazewell County, Ill. An account of their season's history.]

1846. PRAIRIE FARMER, VI, 134. "The Chinch-bug."

[Injuries in Sangamon County, Ill.]

PRAIRIE FARMER, VI, 245. "Chinch-bugs."

[Injuries in Cass County, Ill.]

1850. LEBARON, WM.—"*Rhyparochromus devastator*." Prairie Farmer, Vol. X, p. 200.

[Describes imago, and proposes specific name *devastator*; mentions that eggs are deposited on roots; points out its destructive characters as an insect enemy.]

1851. HARRIS, THADDEUS W.—"Chinch-bug."—Cultivator, Albany, December, 1851, VIII, No. 12, p. 402, 403.

[Not seen; from Hagen's Bibl. Entom.]

1851. PRAIRIE FARMER, XI, 335. "The Chinch-bug."

[Distribution within the State of Illinois.]

1852. HARRIS, T. W.—"*Rhyparochromus leucopterus*." Treatise on insects of Massachusetts.

[Describes briefly imago; speaks of distribution and injuries; records finding in his garden in 1852.]

1855. FITCH, ASA.—"*Micropus leucopterus*." The Cultivator, 3d series, III, 237–239.

[Correspondent writes from Indiana. Fitch gives account of habits and injuries, past history and nomenclature.]

1856. FITCH, ASA.—"*Micropus leucopterus.*" 2d Rep. Ins. N. Y., pp. 277–297, Plate IV, figs. 2 and 2^a.

[Gives 1783 as date when first known as insect depredator on wheat in North Carolina; notes its occurrence at several times during next fifty years in such numbers as to nearly destroy the wheat crop; farmers ceased to plant wheat for a couple of years as only known remedy; alludes to drought which prevailed during period of injury, and their destruction by wet weather, 1840; first attracted attention in Western States 1840–'44; describes young larvæ; mentions briefly a number of varieties; gives history of nomenclature; suggests spraying infested fields as a practical remedy.]

1857. SIGNORET, V.—"*Micropus leucopterus,*" Say. Essai monographique du Genre Micropus, Spinola, Ann. Soc. Ent. de France, V, 3d series, p. 31.

[A technical description from specimens received from New York and Cuba.]

1861. WALSH, B. D.—"Chinch-bug." Insects injurious to vegetation in Illinois. Trans. Ill. State Agr. Soc., Vol. IV, 1859–'60, pp. 346–349.

[First notice of four Lady-bird enemies of the Chinch Bug. Figures *Hipp. maculata* and *Coccinella munda.*]

1862. HARRIS, T. W.—"*Rhyparochromus leucopterus.*" Insects injurious to vegetation. Third ed., pp. 197–200, fig. 84.

[See under 1852.]

1864. BUDD, JOSEPH L.—"Chinch Bugs." The best way to manage them. Prairie Farmer, July 16, 1864 [V. XXX], n. s., V–XIV, p. 36.

[Recommends early and thick sowing and rolling.]

Review by "Agricola," entitled "Another word about Chinch-bugs; how to use them." *Op. cit.*, July 23, p. 52.

Reply to Agricola's review, by J. L. Budd, entitled "Chinch-bug. Objection to deep covering of spring wheat." *Op. cit.*, August 6, p. 84.

1865. RILEY, C. V.—The Chinch Bug. Prairie Farmer, September 19, 1865.

[Exposes the fallacy of a reported observation by Mr. D. H. Sherman in the Waukegan Gazette, to the effect that the eggs are laid upon the wheat-head.]

1866. WALSH, B. D.—"Chinch-bugs." Practical Entomologist, Vol. I, p. 95.

[Prints a clipping from Prairie Farmer stating that the "bugs" had been successfully fenced out of a field by putting boards on edge around it and coating upper edge with coal-tar.]

1866. CANADA FARMER, December 1.—"The Chinch-bug."

[Occurrence of *Blissus leucopterus* hibernating at Grimsby, Ontario; account of habits and seasons; quotes Prairie Farmer for remedies.]

1866. RILEY, C. V.—"Chinch-bug." Prac. Ent., Vol. I, No. 6, p. 47.

[Exposes fallacy of a current theory that the eggs are deposited on the grain and fields become infested from its use; gives methods of depositing eggs and states that there are two generations in northern Illinois and possibly three in more southern latitudes.]

1866. WALSH, B. D.—"*Micropus* (*Lygæus*) *leucopterus.*" Pract. Ent., Vol. II, p. 21.

[Notices specimens of short-winged variety from Canada.]

1867. SHIMER, HENRY.—"*Micropus* (*Lygæus*) *leucopterus.*" Proc. Acad. Nat. Sci. Phila., Vol. XIX, pp. 75–80.

[Full journal account of observations during 1864–'65 in Illinois; conclusions as to causes of their destruction in 1865, p. 234; reference to epidemic.]

1869. WALSH AND RILEY.—"*Micropus leucopterus.*" Am. Ent., Vol. I, pp. 169–177, fig. 122.

[Popular inferences, past history, natural history, checks to multiplication; review of Dr. Shimer's prophecies about appearance.]

Ibid., pp. 194–199, figs. 138, 139.

[Predaceous foes of, damages done by, remedies for; summary of four conclusions: (1) They hibernate in imago stage in rubbish which should be burned; (2) early sowing in spring is an advantage; (3) compacting the soil acts as preventive; (4) heavy rains always injure or entirely destroy them.]

1869. PACKARD, A. S., Jr.—"*Blissus leucopterus.*" Guide to the Study of Insects, pp. 543, 544, fig. 547.

[Describes imago, life history, injuries of, epidemic diseases of 1865; cites its occurrence in Maine and at summit of Mount Washington; notices the theory that wet weather during breeding season is destructive to them.]

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[An extended account and the best yet published; discusses past history, natural history, destructive powers, heavy rains, natural enemies, amount of damage, remedies, and bogus Chinch Bugs.]

1871. GLOVER, TOWNEND.—"*Rhyparochromus (Micropus) leucopterus.*" Rep. Com. Agr., 1870, p. 89.

[Refers to observations of others as to depositions of eggs, etc.]

1872. BETHUNE, C. J. S.—"*Micropus leucopterus.*" Rep. Ent. Soc. Ont., 1871, p. 55.

[Refers to accounts of early history, habits, enemies of, natural remedies, etc.]

1872. LEBARON, WM.—"*Micropus leucopterus.*" 2d Rep. State Ent. Ill., 1871, pp. 142–156.

[Estimates loss from depredations current year in Illinois, $10,500,000; treats of their prevention and destruction under five heads: (1) Natural enemies, (2) early sowing, (3) preventing migrations, (4) destroying by burning rubbish, (5) cease cultivating the affected crops.]

1872. GLOVER, TOWNEND.—"*Rhyparochromus leucopterus.*" Rep. Com. Agr., 1871, p. 84.

[Merely refers to its injuries in Western States, and mentions salt being used as a remedy.]

1872. LEBARON, WM.—"Chinch-bug." Experience of 1872. Prairie Farmer, August 24.

[Believes that a sufficient number of these insects hibernate under dead leaves in the woods to perpetuate the species; also that the wet spring of 1872 destroyed large numbers of the Chinch Bugs.]

1874. GLOVER, TOWNEND.—"*Micropus (Rhyparochromus) leucopterus.*" Rep. U. S. Comr. Agr., 1872, p. 121.

[Mentions injuries in Western States to Corn, Wheat, Sorghum, etc.; three broods reported observed in Missouri.]

1874. JOHNSON, B. F.—"Chinch-bug." Country Gentleman, Vol. XXXIX, p. 661.

[Abundant in central Illinois; stock was poisoned by eating fodder; suggests sowing plats of noxious plants, tobacco, nightshade, henbane, stramonium, hemp, etc., to assist in checking their ravages.]

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[Gives localities in Southern and Western States where reported as injurious.]

1875. RILEY, C. V.—"*Micropus leucopterus.*" 7th Rep. State Ent. Mo., pp. 19–50; Appendix, pp. 51–71, figs. 2, 3, and 4.

[Résumé of previous history; full descriptions of various stages; natural history; extended account of injuries in 1874; exhaustive discussion of preventive measures and remedies; mentions irrigation; predaceous enemies. Appendix, correspondence of farmers.]

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1876. UHLER, P. R.—"*Blissus leucopterus.*" List of Hemiptera of the region west of the Mississippi River, including those collected during the Hayden Explorations of 1873. Bulletin U. S. Geol. and Geog. Sur. Terr., I, second series. No. 2, p. 306.

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[Refers to its destructiveness in the Western States; quotes estimates of different State entomologists; notices briefly some of the remedies for.]

1878. THOMAS, CYRUS.—"*Blissus leucopterus.*" 7th Rep. State Ent. Ill., pp. 40–71, 2 figs.

[Résumé of history, natural history, descriptions, etc.; two brooded in northern Illinois, possibly three in southern Illinois; remedies and general discussion of same.]

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[Discusses weather influence and advances parallel between Rocky Mountain Locust and Chinch Bug; review of life history and summary of facts from Seventh Mo. Rept.; prediction of bugs in 1879 if weather prove dry.]

1879. THOMAS, CYRUS.—"*Blissus leucopterus.*" Bull. U. S. Ent. Com. No. 5. Ten figures, map showing distribution.

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[An account of damage to sorghum cane by the Chinch Bug.]

1880. Thomas, Cyrus.—Temperature and rain-fall as affecting the Chinch-bug. Am. Ent., new series, Vol. I, pp. 240–242, with diagram.

[Condensation of his theory about periodicity of seasons of drought and their relation to appearance of this insect.]

1881. Thomas Cyrus.—"The relation of metereological conditions to insect development." 10th Rep. State Ent. Ill., pp. 47–59, with diagram.

[Discusses theory of septenary cycles of meterological conditions; believes it possible to predict with considerable certainty the season when Chinch Bugs will appear in injurious numbers.]

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1881. Riley, C. V.—Am. Agriculturist, November and December, 1881.

[Reviews natural history and remedies, and discusses the practicability of irrigation as a remedy.]

1882. Howard, L. O.—Rep. U. S. Dept. Agr., 1881–'82, p. 137.

[Mentions it as infesting rice affected by "white blast."]

1882. Riley, C. V.—"Chinch-bug Notes." Rep. Com. U. S. Dept. Agr., 1881–'82, pp. 87–89.

[Calls attention to Professor Thomas' prediction of injury during 1881, and the fact that it was partially fulfilled; discusses briefly remedies and methods of prevention.]

1882. Forbes, S. A.—"Bacterium, a parasite of the Chinch-bug." Am. Nat., Vol. XVI, p. 824.

[Account of discovery of parasitic disease among Chinch Bugs.]

1882. Forbes, S. A.—"*Blissus leucopterus.*" 12th Rep. State Ent. Ill., pp. 32–63, Fig. 6.

[Gives full account of observations on life history, etc., for the year; insect enemies; a new insect enemy; bird enemies; account of observation on a bacterium parasite; experiments in drenching with water under artificial conditions not fully carried out; report of experiments with topical applications.]

1882. Riley, C. V.—"The Chinch-bug." Am. Agriculturist, p. 476, 3 figs.

[General account of habits and natural history; meterological conditions affecting.]

1883. Lintner, J. A.—Cir. No. 1, N. Y. St. Mus. Nat. Hist.

[Directions for arresting Chinch-bug invasion of northern New York.]

1883. Lintner, J. A.—"The Chinch-bug in New York." Country Gentleman, November 8, 1883.

[Directions for co-operating among farmers to prevent ravages coming year.]

1883. Forbes, S. A.—"Experiments on Chinch-bug." U. S. Dept. Agr., Div. Ent., Bull. No. 2.

[Memoranda of experiments with kerosene emulsion and mixtures made at suggestion of Prof. Riley; found them quite effective.]

1883. Forbes, S. A.—Entomological notes of the season. State Dept. Agr. Cir. 106, Illinois crops for 1883, p. 177.

[Notes the deposition of eggs for first brood on the roots of Indian corn.]

1883. Saunders, Wm.—"*Micropus leucopterus.*" Rep. Ent. Soc. Ont., pp. 59–62.

[Account of appearance in New York; quotes from Lintner.]

1883. Riley, C. V.—"Chinch-bug in New York." Science, Vol. II, 1883, p. 621.

[Cites facts to show that their appearance in New York is not an invasion, but extraordinary development of the species, dependent upon climatic conditions.]

1884. Riley, C. V.—"The Chinch-bug in New York State." American Naturalist, January, 1884, XVIII, pp. 79, 80.

[A reprint of an unplaced article in Scientific American criticising Dr. Lintner's conclusions as to reasons for alarm in northern New York.]

1884. Lintner, J. A.—Thirty-seventh Ann. Rep. N. Y. St. Mus. Nat. Hist., pp. 53–60.

[Not seen.]

1885. Bruner, Lawrence.—"*Blissus leucopterus.*" Rep. Com. Agr. 1884, p. 399.

[Cites an instance where large numbers disappeared immediately after a heavy rain.]

1885. Riley, C. V.—"Chinch-bug Notes." Rep. Comr. Agr. 1884, pp. 403–405.

[Refers to occurrence in New York, and considers that there is no cause for alarm; predicts they will attract no further notice.]

1885. Forbes, S. A.—Ent. Calendar. 14th Rep. St. Ent. Ill., pp. 4, 5.

[Notes on life history for year 1884.]

1885. LINTNER, J. A.—"*Blissus leucopterus.*" 2d Rep. State Ent. N. Y., pp. 148–164, figs. 37, 38, 39, and 40.

[Account of its occurrence in northern New York; résumé of its history, life history; remedial measures employed and recommended.]

1886. HUNT, THOMAS F.—"*Blissus leucopterus.*" Bibliography of insects injurious to corn. Misc. Essays on Economic Ent., Ill, St. Bd. Agr., 1885.

1886. WEBSTER. F. M.—"*Blissus leucopterus.*" Insects affecting fall wheat. Rept. of Ent., Ann. Rept. Comm. of Agr., 1885, p. 318.

[A brief record of Chinch-bug observations during the season; records a Mermis as a possible parasite.]

1886. FORBES, S. A.—"Chinch-bug in Illinois." Circular of information from the office of the State Entomologist.

1887. BRUNER, LAWRENCE.—Notes of the season. Bull. No. 13, Div. Ent., U. S. Dept. Agr., pp. 34, 35.

[Brief notices of their appearance in Western States in 1886.]

1887. FORBES, S. A.—The present condition and prospects of the Chinch-bug in Illinois for 1887–'88. Bull. No. 2 of the State Entomologist.

[Speaks of ravages for three years past, life history, food-plants; preventive remedial measures exhaustively discussed.]

THE CODLING MOTH.

(*Carpocapsa pomonella*, L.)

Order LEPIDOPTERA; family TORTRICIDÆ.

[PLATE II.]

By L. O. HOWARD.

INTRODUCTORY.

The Codling Moth is another of those important insects which have a vast newspaper literature and the habits of which are tolerably well known to most persons who suffer from their attacks, but of which there is, in present accessible form, no complete account. At the instance of Professor Riley, who has turned over to me all his notes and scraps, this article is therefore prepared, and its purpose is to bring into one readily-accessible article a review of the life history and a somewhat extended account of the remedies. Some new facts are introduced, and the latest experiments are summarized.

There is no insect injurious to fruits in this country, with the single exception of the Plum Curculio, which has been written about so largely as the Codling Moth. We had proposed adding a bibliographical list of the American writings, as in the case of the Chinch-bug, but soon found that it would consume altogether more space than could be allowed. References to the articles consulted will, however, be found in the text. The most important of them have been Professor Riley's, in the first, third, fourth, fifth, and sixth reports on the insects of Missouri; LeBaron's, in his second report as State Entomologist of Illinois; Dr. Trimble's, in his Insect Enemies of Fruit and Fruit Trees; and the more recent ones, treating of remedies only, by Chapin, A. J. Cook, and Forbes.

The familiarity of fruit-growers with the habits of the Codling Moth is hardly to be wondered at, in view of this multiplicity of literature, and to this familiarity is due the gradual improvement of the appearance of the apples found in market of late years. Before the use of the arsenical remedies it was a difficult thing for a single

fruit-grower to grow comparatively wormless apples without combining in the use of the band system with the orchardists of a neighborhood, on account of the inevitable restocking from adjoining orchards. Now, however, with the poisoned spray, the individual may keep his apples nearly perfect, no matter how careless his neighbors may be. The poisoning has the additional advantage over the bands that it prevents the damage of the brood to which it is applied, while the bands only capture the worms after they have done their damage, and thus lessen the numbers of the succeeding brood.

As in the preparation of the previous article, I have had free access to Professor Riley's notes, and to those of the Division.

GEOGRAPHICAL DISTRIBUTION.

The Codling Moth is originally a European insect, although it is now cosmopolitan. All of the European works on garden insects contain accounts of this species, which is called in most of the older ones *Tortrix pomonana*. It is an insect which is comparatively easy of importation from one country to another, on account of its wintering in the pupa state and of the habit which the larvæ have of creeping into crevices of all kinds to spin their cocoons; so that in trees, and more particularly in the cracks of the crates or boxes or barrels in which apples are shipped from one country to another, the insect finds a hiding-place and the little moth eventually appears. It has thus found its way all over the United States, making its first appearance in California, at Sacramento, in 1874. It is found in nearly all of the English colonies, in South Africa, in New Zealand, in Australia, and in Tasmania. There is no record of its occurrence in South America, although, in spite of the fact that it is a northern insect in appearance, it is found equally in Siberia, so far as apple culture extends, and in the sub-tropical region of northern Van Dieman's Land. In many of the English colonies it has only recently appeared, and the investigations and reports of special committees and the laws and regulations which have been enacted concerning it in these colonies would fill a large volume. It was introduced into America certainly before the beginning of the present century, but it is impossible to fix anything like an exact date.

THE INSECT POPULARLY DESCRIBED.

The larva is whitish when young, but becomes pinkish or flesh-colored as it approaches full growth (Plate II, figs. 1 and 5*a*). When young the head is blackish, but in the full-grown larva it is brown, with darker markings along the sutures. The shield on the back of the first segment is of the same color as the head. The body is furnished with a few very small hairs, which arise from minute elevated points, of which there are eight on each segment, two on the back each side of the middle line, and a somewhat larger one above and below each spiracle. The full-grown larva is from 15 to 18 millimeters long.

The cocoon is white inside and grayish outside, usually covered somewhat with bits of bark or minute fragments of whatever substance the worm happens to spin on. The inclosed pupa (Plate II, fig. 2) is yellowish brown, with rows of minute teeth on the back of the abdomen.

The moth (Plate II, figs. 3, 4, and 5) expands about 20 millimeters, and its general effect is grayish brown. Examining closely, we see that the fore-wings are marked with alternate irregular transverse streaks of gray and brown, and that there is a large, rounded tawny spot on the outer hind angle. This spot is marked with streaks of bronze or gold, and there are similar streaks just above it. The hind wings are brown, grading from light to dark from base to tip. The two sexes can be distinguished by a black pencil of hairs on the upper surface of the hind wing of the male only. This pencil is not easily distinguished, but is always present. It was first pointed out by Zeller in 1870, and arises not far from the base of the wing, near the median vein. It runs in a furrow, which is noticeable from the under side as a slight keel. This tuft not only separates the male from the female, but distinguishes *pomonella* from all other species of *Carpocapsa*, although it is found with the males of certain other genera (see Zeller in Stettiner Entomologische Zeitung, 1871, p. 55; and Riley, Third Rept. Ins. Mo., 103).

HABITS AND NATURAL HISTORY.

The habits and natural history of the species are practically the same the world over, although in England and Northern Europe, including Prussia, it seems to be single-brooded. In America it is two-brooded far north into Canada and in the South it is three-brooded. In Austria it is two-brooded, and its habits seem precisely the same as they are in this latitude. Attention has been called to the fact that in colder climates the cocoon is thicker than in warmer countries, but beyond some few differences of this sort the insect lives in the same way everywhere. The round of its life may be briefly summed up as follows: Soon after the blossoms have fallen and the fruit has begun to set, the moths issue from their cocoons in which they have wintered and which are usually situated in cracks in the bark of the trunk of the tree, when they pair and lay their eggs at the apex of the forming fruit. In the little crumpled-up spot caused by the falling off of the calyx the eggs are hidden, sometimes two or three to a single apple or pear. The eggs are laid sometimes upon the smooth cheek of the apple and sometimes in the hollow at the stem, but these are both unusual. The young larvæ on hatching eat their way immediately to the core of the apple, where they live and grow, casting their skins four times, and excavate large and irregular cavities in and around the core, sometimes first eating the seeds. Their excrement is blackish and stains the cavities, which are also still further rendered unpalatable by the threads of silk which the little larva spins wherever it goes.

Usually the castings are pushed out through the hole by which the larva originally entered, and which is enlarged for this purpose from time to time. The infested apples can be detected thus by the mass of excremental pellets issuing from the end.

The larvæ reach full growth in about four weeks from the time of hatching, and the infested apples now begin to fall to the ground. The larva now bores a hole to the side of the apple and, issuing, crawls about for a suitable place to spin its cocoon and transform. In the great majority of instances it returns to the trunk of the tree, and crawling up some distance hides itself in a crevice under some partially detached bit of bark, where the thin, slazy-looking cocoon is spun. Occasionally the apples do not fall, and in this case the larva

on issuing crawls down the trunk instead of up, and usually spins at a higher point, nearer the crotch or even above it. The pupa state of this generation lasts but a short time, usually not more than two weeks. The moths then issue and begin to lay eggs for the second generation. It is estimated that each moth lays about fifty eggs, and these are developed rather slowly, so that the period of oviposition extends over ten days or two weeks. Dr. LeBaron found, on dissection, that while there were on an average fifty tolerably well-developed eggs in the ovaries, there were many others undeveloped, so that the number deposited by each moth may be increased.

Irregularity of development, combined with this slow oviposition, produces the overlapping of generations noticed in so many insects, and which becomes more prominent in insects which have several broods. About the same time full-grown larvæ, young larvæ, eggs, and pupæ will be found. So great does this irregularity occasionally become that moths of the first brood do not issue until on in September, and when the apples are picked they often contain larvæ only recently hatched. Such individuals are retarded, of course, in their growth by cold weather, and we have occasionally found larvæ in eating apples as late as the middle of January which were less than half grown, and one living specimen was brought to us in January 1888, which had not passed its second molt. It is quite likely that such individuals will successfully transform, and we believe that the appearance of their moths will not be greatly retarded beyond those of larvæ which spun their cocoons normally in the fall.

Seldom more than one larva is found in a single apple. When two are found they will usually be found to be of differing sizes, thus indicating that the eggs were laid by different moths. When of the same size, however, it has been noticed that originally the apple hung closely appressed to another, and that both larvæ, originally intended for different apples, by accident entered the same. Dr. S. F. Chapin, to whose careful examination of over three thousand infested apples we have referred in our section on remedies (see also Report Second Annual State Convention California Fruit-growers, 1882 [1883], page 18), found in this large number of apples containing the pest but twenty-four which contained two larvæ each, and one only which contained three larvæ. In but two apples were two larvæ found in the same cavity. The instinct of the moth which leads it to avoid apples already oviposited in and to deposit but one egg on a single apple is modified in confinement, and also probably wherever the moths occur in excess of the food supply. Professor Riley, in his manuscript notes, mentions that he placed a single apple in a breeding-jar with a number of moths, and that in a few days it was fairly riddled with young larvæ. The moth is a night flier and conceals itself by day, and as the oviposition is done by night it is seldom observed. Unlike most night fliers it is not readily attracted by light and is seldom captured by poisoned baits, as will be shown in another section.

The larvæ of the second generation are usually found in the later varieties of apples, and fewer of these fall to the ground in consequence of the insect than is the case with the early varieties. Many of the larvæ reach full growth before late fall and seek the same places for pupation as did the early brood. The cocoon of this brood is thicker than that of the first, as is to be expected, for in it they pass the winter. Often the crop is harvested before many larvæ have escaped for transformation, but the worms complete their

growth in the picked apples and issue just as though they had staid upon the tree, spinning their cocoons in this case in the barrel cracks or in any suitable dark niche or cranny at hand. After spinning its cocoon it does not immediately transform to pupa, but remains in the larval state within the cocoon until nearly spring, and in this inclosed hibernating condition it is by no means passively dormant, as Professor Riley observed during the winter of 1867–'68 that each time he cut open a cocoon to observe the condition of the larva it fastened up the incision.

An apparent exception to the rule that the insect hibernates as a larva was observed on certain specimens received at the Department November 15, 1883, from Mr. M. B. Newman, of Wyandotte, Kans., and which were already in the pupa state on receipt, and in fact when sent (November 12). From these pupæ, which were kept in a comparatively warm room, two moths issued January 8, 1884, and two more January 14. The same gentleman stated, on the authority of Mr. R. B. Armstrong and other orchardists near Wyandotte, that large numbers of dead Codling Moth larvæ were found under the loose bark of the apple trees during October, and which had doubtless been killed by the cold drenching rains which prevailed at that time. We were unable to secure specimens for identification, however, and the statement must remain unverified.

The cocoons of this brood are often found between the staves and hubs of apple barrels. Hundreds can be sometimes found in such locations.

It may be of interest to state that in North Germany, where the insect is single-brooded, the moths make their appearance and deposit their eggs from the middle of June on into July.

FOOD PLANTS.

Although the Codling Moth is above all an apple pest, it is quite a general feeder, and is found in other seed fruits of the same family, such as pears and haws. The stone fruits of the family Rosaceæ are less infested than the others, although it is sometimes found quite abundantly in peaches, and instances are on record showing that it does considerable damage to plums in some localities. Apricots are also infested. It has also been found in Europe in all of these fruits. Outside of the fruits of the family Rosaceæ, however, it is not known in this country.

There are, however, several European records of the occurrence of this insect in walnuts and oak-galls to which we may properly give some consideration. The first of these records appears in a paper by Laboulbène in the Annales de la Societé Entomologique de France, 5th series, Vol. I, 1871, page 295, from which we translate the following paragraphs:

"The shell of the nuts deprived of the green envelope shows often at the point of attachment a blackish hole. The two halves separated show the kernel gnawed and a great quantity of brownish grains made by the excrement of a larva. Moreover, the substance of the nut or the kernel has in places a dark tint, and occasionally the tissue has been spoiled, shriveled, or covered with mold. Finally, in several fruits I have noticed on careful examination silk threads among the brownish excremental pellets.

"I found two whitish worms of medium size with chitinous head and six legs, which are certainly caterpillars. I attributed to these

the silk threads and the excrement which filled the injured nuts. The orifice in the hilum of the nuts was also produced by these caterpillars in the act of leaving the fruit to transform outside.

"But there was also, besides the two caterpillars, a great number of reddish maroon pupæ, which could only belong to a dipterous insect. These were found everywhere in the cavity of the spoiled nuts. At the end of two weeks there issued a number of small black flies. These all belonged to the same species (*Siphonella nucis*) which M. E. Perris made known for the first time in our Annales more than thirty years ago, accompanying his work by numerous figures.

"I have not seen the larvæ of the *Siphonella*, but M. Charles Robin has seen them in the wormy nuts. These larvæ transformed to pupæ during the journey from the Department of the Ain to Paris.

"I confided to the care of M. J. Fallou the two caterpillars mentioned. One of them after pupating produced *Carpocapsa pomonana.*

"* * * In my opinion the larva of *Siphonella nucis* lives upon spoiled material, perhaps upon the excrement of other larvæ, and is not to be relegated to the same rank as the *Carpocapsa* for the damage which it causes. M. Perris has distinctly stated that it is not a parasite; it lives by the damage done by the *Carpocapsa*, which is in reality the principal author of the injuries which render the nuts worm-eaten."

The fact that this insect was a true Codling Moth rests entirely upon the determination of Mr. Fallou. On referring to the bulletin of the same society for December 27, 1871, page 85, we find that Laboulbène stated that the specimen bred by Mr. Fallou was destroyed during the sack of the city of Chateaudun by the German army. In speaking of it he makes use of the following somewhat significant sentences: "This Lepidopter was so near *Carpocapsa pomonana*, Hübner (*pomonella*, L.), that it was referred to this species. However, to make sure, Mr. Fallou sent it to Mr. Guenée, who is so great an authority upon such matters. We know what became of the specimen. In order to state positively that the lepidopterous insect injurious to walnuts is the same as that which injures our apples it will be necessary to raise a great number and so determine it irrefutably. I call this fact to the attention of competent entomologists."

Even in this state of comparative doubt, however, the fact seems to have been accepted by other entomologists. The record is quoted without question in the Zoölogical Record for 1871, page 380.

In the Entomologist's Monthly Magazine, Vol. XV (1874), page 13, Mr. C. G. Barret states that Mr. W. West "tells him that he has reared the perfect insect [*C. pomonella*] from a larva which he found feeding in a walnut. Without intending a slur upon Mr. West's competency, we may simply draw attention to the fact that this determination does not seem to have been verified by any well-known entomologist.

In the bulletin of the Societé Entomologique de France for May 10, 1876, Mr. Ragonot makes the similar statement that this insect has been reared from walnuts, although he does not give it as a personal observation, and it is probably simply a reference to Mr. Fallou's rearing.

The probability of a uniformity of habit in this species must be our excuse for endeavoring to show that these observations are not well supported, and we may refer to the fact that a closely allied species (*Carpocapsa putaminana*, Staud.) seems to be quite well

known to feed upon walnuts in the way described by Laboulbène in Brussa, Andalusia, and in Italy, also in Austria. The larva of this insect was taken by Zeller while in Italy for that of *pomonella*, but in the Stettiner Entomologische Zeitung for 1871, Vol. XXXII, pages 55, 56, he states that it belongs rather to Staudinger's *putaminana*. This, of course, immediately suggests the possibility of a mistake in determination on the part of Messrs. Fallou and West. The Fallou specimen has been destroyed as above stated, but if the West specimen is still in existence we would urge the importance of examination of it upon English entomologists.

The oak-gall observation is recorded by Ragonot (*loc. cit.*). It seems that Mr. Bonnaire had collected a number of oak apples (galls of *Cynips quercus-folii*) in the autumn, and that in the following spring there appeared a single Codling Moth in addition to the usual tenants of these galls. Mr. Bonnaire affirmed that his box contained nothing but these galls. Ragonot makes no comments upon this statement, but his silence seems to accept the fact. It seems to us, however, rather unlikely, and it is possible that the *Carpocapsa* larva in seeking a place to spin its cocoon had either found its way into a broken gall before the collecting, or, emerging from a picked apple, had found some crevice in the box a convenient place for its cocoon. We can hardly believe that it fed and developed on the gall substance.

NATURAL ENEMIES.

Almost all orchard birds will feed upon the Codling Moth in one state or another. The Woodpeckers and the Creepers and the Black-capped Titmouse which run up and down the bark of a tree find the cocoons in the crevices and quickly rob them of the inclosed pupæ. The Downy Woodpecker (*Dryobates pubescens*) and the Chickadee (*Parus atricapillus*) have been shot by Trimble and proven by their stomach contents to feed upon the Codling Moth larva.

A hair snake (*Mermis acuminata*, Siebold) has been found by several observers in this country coiled around in the core of infested apples, and undoubtedly infests the larva of the Codling Moth. Professor Riley has five specimens from this source, varying from 5 to 8 inches in length. This species, which is considered by certain European authors as but a parasitic, non-sexual form of *Mermis albicans*, has been taken from several different insects in addition to the Codling Moth (see 1st Rep. U. S. Entomological Commission, 1877, p. 327). It was first determined from the apple-inhabiting individuals by Dr. Leidy (see Proc. Acad. Nat. Sc. Phil., XXVII, 1875, p. 15), who had mentioned the same worm in the proceedings of the same society for 1850, p. 117, as obtained from a child's mouth. In his 1875 paper he explained this latter occurrence on the ground that the child had probably eaten an infected apple. This *Mermis* has been taken also by Mr. P. H. Foster, of Babylon, L. I., directly from Codling Moth larvæ found concealed under bands.

Of true hymenopterous parasites at least three species have been recorded in Europe and two have been bred in this country. The European species are *Phygadeuon brevis*, Grav., *Pachymerus vulnerator*, and *Campoplex pomorum*, Ratz., all Ichneumonids. The species which infest it in this country are also Ichneumonids and are *Pimpla annulipes*, Br., (Plate II, Fig. 7,) and *Macrocentrus delicatus*, Cress., (Plate II, Fig. 8.). Both of these insects were first recorded by Professor Riley, who reared them from the Codling Moth in Mis-

souri in 1872. The *Pimpla* is quite a wide-spread species in all parts of the country and is not by any means confined to the Codling Moth. Professor Riley has recorded it from the Walnut Case-bearer (*Acrobasis juglandis*) and has also reared it from the Cotton Worm of the South (*Aletia xylina*) and from *Grapholitha olivaceana*, Riley, *Coleophora cinerella*, Cham., *Orgyia leucostigma*, Har., and an unknown leaf-roller on Ash. It does not seem to spin a cocoon, but eats its way out of the pupa in which it has transformed, usually coming out of the anterior part.

Recently it has been sent to us from Alameda, Cal., where it was reared from the Codling Moth pupa by Mr. Koebele. The *Macrocentrus* is, so far as we know, confined to this one host. It is apparently a more efficient destroyer of the pest than is the *Pimpla*. We have seen large series of individuals in several collections and it is as common at the East as it is in the West. It spins a tough brown cocoon within that of the *Carpocapsa*.

There are a great many predaceous insects which feed upon the larvæ while they are searching for suitable places to spin up, and upon the pupæ, which are poorly protected by the delicate cocoon. None, so far as we know, seek the larva in the apple. Professor Riley states that the Pennsylvania Soldier-beetle (*Chauliognathus pennsylvanicus* DeG., Plate III, fig. 15) and the Two-lined Soldier-beetle (*Telephorus bilineatus*, Say) in their larval states feed upon the larvæ of the Codling Moth after they have issued from the apples. He also mentions the fact that the larvæ of a species of *Trogosita* also helps in this good work. Dr. LeBaron treats of this insect at some length, but of late years it has not been found. The species has never been determined. Mr. Koebele has recently sent us from California two Dermestid beetles, which are stated to destroy the pupæ of the Codling Moth. These are *Trogoderma tarsale* and *Perimegatoma variegatum*. Experiments made indicate that they will kill the chrysalids in confinement, but as to destroying them in the open air on trees we have no absolute evidence. Mr. Keobele has, however, been instructed to make close observations upon this point. An undetermined Soldier-bug was observed by Mr. G. W. Shaw, a correspondent of Dr. LeBaron's, who states that he has actually observed the bug to pierce an apple with its beak and draw out the apple-worm, which, however, is a statement which may be taken with a great deal of allowance. An unbred and undetermined coleopterous larva was received by Professor Riley in 1874 from Prof. A. J. Cook, with the statement that it fed upon both larvæ and pupæ of *Carpocapsa pomonella*. This larva, according to Professor Riley's notes, bore a close resemblance to that of the Clerid *Necrobia rufipes*—the Red-legged Ham-beetle.

REMEDIES.

Under this head we shall discuss only such methods as are of considerable practical utility, not dwelling upon the methods which have been proven by experience to be of little avail. The remedies here considered, viz, the destruction of windfalls—feeding and trampling—the use of sheep and hogs, jarring or picking, confining the moths which issue in store-rooms, store-houses, or barns, the bandage traps, and the use of arsenical mixtures, are all simple and more or less effective. In a badly-infested orchard all could be used to good advantage.

THE DESTRUCTION OF WINDFALLS.—FEEDING AND TRAMPLING—THE USE OF SHEEP AND HOGS.—This remedy is one of the oldest in use and may be used with good results. There is no question but that a great many of the larvæ which fall with the apples, which we have elsewhere shown constitute the larger proportion, are destroyed by stock pastured in this way. We can do no better under this head than re-produce one of the best of the many accounts by men who have tried this method. This is a statement by Mr. J. S. Woodward in the New York Weekly Tribune for June 9, 1880:

"My apple orchard covers 32 acres of ground, and in addition to making a run for some 30 hogs, I have during the past two years kept from 150 to 200 sheep and lambs in it during the summer. I have just brought the sheep (May 21) and turned them in for this season. Of course that amount of land, if it was in good seeding and free from trees, would not pasture so much stock, but in addition to the pasture, I feed enough grain and wheat bran to keep them in such condition that the lambs shall be large enough to wean in July, and the sheep sufficiently thrifty to at once accept the buck after weaning the lambs, and thus drop their next lambs for early winter feeding next winter.

"This, I find, costs me less than to hire the same number pastured by the week, and being crowded they eat every fallen apple as soon as dropped; for the latter purpose I find sheep much better than hogs, for while the hogs sleep so soundly as not to hear an apple drop if only a few feet away, a sheep never sleeps, so that it is on hand for every apple as soon as it touches the ground.

"I let them run here until time to gather winter fruit, and although they will eat a few apples and a few twigs from the ends of the lower limbs, as they bend down with the load of fruit, I find my fruit each year growing fairer, with less and less wormy apples, and my trees, manured with the feeding of so much grain, are looking remarkably healthy and are productive. To prevent their gnawing the smaller trees I wash the trunks with a solution of soap-suds, whale-oil soap, and sheep manure about once each month, and besides I give the sheep a constant and full supply of fresh water; this is very important, for in hot weather they get very thirsty, and will eat the bark from the largest trees even, unless they have plenty of water.

"I like this manner of treating my orchard very much. What it would cost me to hire the sheep pastured each week will buy at least 600 pounds of bran and 400 pounds of corn, making an aggregate each summer of over 10 tons of the very best kind of fertilizer for an orchard. For the money I pay for feed I get my sheep kept in the finest condition, have the lambs growing finely all summer, and have the whole amount of feed bought (which is worth all it costs for that purpose) scattered about the orchard in the best possible condition and manner. Thus, you see, I prove that it is perfectly practicable to 'eat my cake and have it, too,' or, in other words, to get twice value received for the money invested, besides having the Codling Moth successfully trapped."

Where it is inconvenient or impossible to pasture sheep or hogs in an orchard, the immediate collecting of windfalls by hand, in which the services of children can be utilized, is often a valuable adjunct to the use of the band system.

JARRING OR PICKING INFESTED FRUIT FROM THE TREES.—The plan of jarring the trees or of knocking off or picking the infested fruit has been practiced by some orchardists with considerable suc-

cess. It is, however, a laborious method when compared with either the band system or with the early spraying of the trees, and is only of practical utility in very small orchards, or where only a few choice trees are to be protected, as in a door-yard. Mr. Oliver Chapin, of East Bloomfield, N. Y., as reported by Professor Riley in his Fourth Report on the Insects of Missouri, p. 26, was accustomed to send two men with poles through the orchard, who directly tapped those apples from the tip of which the excrement of the worm could be seen exuding. A boy collected the apples and afterwards threw them into a stream or into a kettle of hot water. This was done from the middle of July on. Professor Riley urged a general jarring of the trees with a rubber-tipped mallet or pole earlier in the season, and also suggested boiling the fruit and feeding it to hogs.

Mr. Barnes, of Bloomingdale, Ill., according to Dr. LeBaron, adopted the method of picking off the apples which appeared to be infested, by means of a wire hook attached to a long pole, and picking with the aid of ladders was resorted to as supplementary to the destruction of windfalls and the use of bands by Dr. Chapin in California, as we have related in another section of this article.

KILLING THE MOTH.—Although the destruction of the moth has received some attention, there is really but one suggestion to make which is of any importance, and that is as follows:

Inasmuch as many apples are picked in the fall before the worms have emerged for pupation, the larvæ must spin their cocoons in or near the receptacle in which the apples are stored for the winter, and consequently the moths must issue in spring in considerable numbers in the cellars or store-rooms where the fruit is kept. Flying out through open windows or doors, they naturally make their way to the orchard and start a numerous progeny. It becomes necessary then in May, June, and July, and earlier, according to locality, to keep the doors and windows of such store-rooms tightly closed, or, better still, fit them with wire screens.

Observations made during 1882 by Miss Alice B. Walton, at Muscatine, Iowa, showed that the insects wintering in cocoons in apple barrels in the cellar remained in the larva state, in one instance at least, as late as June 29, upon which date it changed to pupa. The moths emerged in her cellar from June 27 to July 13, although at the latter date outside worms from early out-door moths had become full grown and the apples had begun to fall. From two apple barrels she raised "between three and four dozen moths," which well illustrates the necessity for some measure to prevent their escape. Where it is possible and easy, changing the barrels and treating the old ones with hot water will accomplish the result and avoid the necessity for screens, and barrels which have been emptied during the winter should always be so treated.

The observations on this point made by Mr. F. C. DeLong, of Marin, Cal., are of great interest and place in the strongest light the necessity for a thorough scalding of the barrels, boxes, or crates, and of screens for the windows of the store-house or barn. It seems that on the Novato Ranch there are 31,000 trees on 250 acres of land, and that the Codling Moth was not noticed there until June, 1881, when Mr. Matthew Cooke discovered a single pupa. Later the fruit was gathered and carried into the apple house, very few affected apples being noticed. During the winter months Mr. DeLong had mosquito netting put over all of the windows, and nailed up all of the doors except one, the key of which he put in the possession of a

trusty man. The moths began to appear about the middle of April, and up to May 27, 2,671 had been killed and counted. From May 28 on a daily count was kept, and the moths issued in great numbers until nearly the end of August. The number caught and killed altogether by Mr. DeLong's assistant was 15,627, and the highest catch for a single day was 990 on June 15.* It transpired, moreover, in the discussion of this statement, that a large number of bats were accidentally shut into this same apple house and that doubtless many additional Codling Moths were killed by these insectivorous creatures.

The accounts of the capture of the moths with baits of diluted vinegar and molasses and with other similar substances and at light, which have occasionally appeared, are probably the results of mistaken identity, as are also in all probability the accounts of the capture of the moth by plants of the genus *Physianthus*, which have recently attracted much attention in New Zealand and California. The insect-catching properties of the flowers of the different species of *Physianthus* have long been known, but we very much doubt whether Codling Moths are ever extensively caught by these flowers. Dr. Le Baron observed the moths feeding upon moist sugar and slices of apple in confinement, but they have never been found frequenting flowers or feeding out-of-doors in a state of nature. Professor Riley has treated of the *Physianthus* plant in the Transactions of the Saint Louis Academy of Science, vol. III, p. cxv, and in the American Entomologist, vol. III, p. 75 (March, 1880), and we may add that he now states, after fifteen years' experience with this plant, he has never found that it has captured a Codling Moth, even where grown close to apple orchards. Officially attention was called to this *Physianthus* matter by J. T. Campbell, United States consul at Auckland, New Zealand, who was interested in it through Dr. Cheeseman, of the Auckland Museum, with whom the various reports published the past summer by the Country Gentleman, Prairie Farmer, and other papers originated. After receiving Mr. Campbell's dispatch through the State Department we wrote him, urging him to make certain, in the first place, that there were actual Codling Moths among those captured by the flowers, and, in the second place, if there were such, to examine them carefully to determine whether they were males or females, and if the latter, whether they had oviposited. Mr. Campbell replied that, while he could state positively that the moths found in the flowers were Codling Moths, no examination had been made to determine sex or the relation of the time of capture to time of oviposition. We have since received a very large number of specimens from him, but among them not a single Codling Moth and not even a single Tortricid. All were unrecognizable Noctuids and Pyralids. It is proposed to train these vines up the trunks of apple trees with the surmise that the flowers, by capturing the moths, will protect the crop.

In summarizing the whole question of the possibility of attracting the moth we can not do better than quote the two following paragraphs from Professor Riley's Fourth Report on the Insects of Missouri, p. 27, as it so effectually answers the many published suggestions to the effect that such remedies are practicable:

"I have elsewhere given it as my decided opinion that neither fires, lights, or bottles of sweetened water, vinegar, or of any other liquid,

* See Official Rep. 2d Ann. State Conv. Cal. Fruit-growers, San Francisco, 1883, p. 21.

can be used with any degree of success in fighting the Codling Moth, and I have good reasons for so doing. During one whole summer, three years ago, I had a patent moth-catcher constantly in a garden surrounded by several old apple trees badly infested with this insect, and I never caught a single specimen of *Carpocapsa pomonella.* The trap was made of bright tin, with an inverted cone so placed in a basin that I could attach a light and fill the basin with sweetened fluid. Again, during the summer of 1870, I was in the habit of working till late at night in an office surrounded by apple orchards known to be badly infested. I worked by the aid of two large kerosene lamps, each having a strong reflector, and the light in the room was so bright as to form a constant subject of conversation among the neighbors. Insects of one kind and another would fly into the room by hundreds, and on certain warm, moist evenings would beat against the windows with such rapidity as to remind one of the pattering of rain. Yet, during that whole summer I caught but one or two Codling Moths in that room, and there was more reason to believe that they had bred in the house than that they were attracted from without.

"At the same time I had hung up in an orchard close by, many wide-mouthed bottles, half-filled with various liquids, such as diluted sirup, sugar water, and vinegar more or less diluted. Every two or three days these bottles would contain great numbers of insects, which were critically examined. Many of them would be small moths of one kind and another; some of them larger moths, known to be injurious, and many other insects—such as beetles, true bugs, wasps and two-winged flies—that were beneficial. Indeed, there were almost as many beneficial as injurious species, and, as I shall presently show, the only two species yet known to prey on *Carpocapsa pomonella* were among the more numerous victims of these hanging bottles. From my notes I find that but three Codling Moths were caught in these bottles during the summer. Indeed, so small is the proportion of Codling Moths which I have caught by the above-mentioned process, that the chances of their accidentally flying into such situations are about as great as of their being attracted. I might add further experience on this head, but it is unnecessary. Upon showing specimens of the Codling Moth to many dozens of eminent and intelligent fruit-growers who have had to do with apple orchards, and consequently with apple worms, most of their lives, I have seldom found one who did not candidly confess that he had never before identified the insect; and under these circumstances it is not surprising that other similar moths should have been mistaken for the genuine article. The moth is, therefore, occasionally caught in such traps, and in the face of other intelligent testimony the fact can not be denied, though the experience on this head of non-entomologists is conflicting. But whether we consider that the few so caught are really attracted, or are captured accidentally, I believe that the methods indicated have no practical value. They are blind ways of shirking the more sure and efficient remedies.

"I have been thus explicit as to these would-be remedies because my statement 'that the Codling Moth was not attracted (to any extent) by light' has been recently quoted by Mr. J. W. Robson as an evidence 'that scientific men don't know everything.' It would be strange indeed if they did, and I have already labored under the impression, somehow or other, that they were the last to claim any such universal knowledge, and that it was the charlatan alone who

was blessed with the knowledge of everything. In the latest work on apple culture that has been given to the public, namely, 'The Apple Culturist, with illustrations, by S. E. Todd,' we naturally look for all that is new and important about this insect which cuts such a figure in apple culture. Alas! what do we find? The descriptive part is a perfect plagiarism, almost word for word, from an article in the American Entomologist (Vol. I, pp. 112–114), all palmed off as original; while under the head of remedies, he concludes his advice as follows: 'By keeping the bottles containing sweetened water and the pan half filled with thin molasses, with a lighted lamp near it in the orchard every night, in good order, almost every insect will be trapped in a few days,' and this excellent (!) advice is accompanied by an illustration of a shallow pan with a kerosene lamp on one edge of it, and 'flies' as thick as a swarm of bees around it."

TRAPPING THE WORM—BANDAGES, SHINGLE TRAPS, ETC.—The fact that the larva of the Codling Moth preferably seeks shelter under loose bark and in crevices on the trunk of the tree before spinning its cocoon long ago gave rise to the practice of affording it for spinning artificial shelter which can be readily examined and in which the insect can be readily destroyed. The first notice of the adoption of such a plan which we have found is by Mr. Joseph Burrelle, of Quincy, Mass., published in the New England Farmer (Vol. XIX, 1840), in which he says, according to Harris, "that if any old cloth is wound around or hung on the crotches of the trees the apple-worms will conceal themselves therein, and by this means thousands of them may be obtained and destroyed from the time when they first begin to leave the apples until the fruit is gathered."

To Dr. I. P. Trimble is generally given the credit for the discovery of the hay band so long used for this purpose, and it is generally known as the "Trimble hay-band system." It is a natural outgrowth of the practice mentioned by Mr. Burrelle. Dr. Trimble, in 1862 or 1863, found an old boot-leg in the crotch of a neighbor's pear tree, and upon examining it he found 16 cocoons of the Codling Moth in its folds. This started his experiments, which were made with leather (chamois skin), old carpet, cloths, and hay rope. His experimentation resulted in his unhesitating recommendation of hay rope wound around the tree in three coils at some little distance from the ground. He also advised the application of other bands to the larger limbs. The rope was fastened as tightly as it could be pulled, and in examining it he simply pushed it up the trunk, replacing it after destroying the cocoons.

Professor Riley, in his First Report on the Insects of Missouri, laid down the following rules concerning the hay-band system: "First, the hay band should be placed around the tree by the 1st of June, and kept on till every apple is off the tree; second, it should be pushed up or down, and the worms and chrysalids crushed that were under it every week, or at the very least every two weeks; third, the trunk of the tree should be kept free from old rough bark, so as to give the worms no other place to shelter; and, fourth, the ground itself should be kept free from rubbish." In his fourth report he advises applying the bands two weeks prior to June 1.

In his fifth report he describes a band somewhat superior to the simple strip of 6-inch wide canvas mentioned in his fourth. It consisted of a strip of old sacking 4 inches wide and lined on one side with pieces of lath, tacked on transversely and at such a distance

from each other that when brought around the tree they formed an almost complete wooden ring.

The Wier shingle trap was patented and put on the market in 1870 or 1871. It consists of three shingles placed at a slight distance from each other on a large screw, which is to be forced into the trunk of the tree. The idea is that the worms descending or ascending the tree and meeting the shingles will crawl between them. The shingles being mounted on a screw can be easily turned apart and examined. This trap is mentioned on account of the interest which it aroused at the time. Experiments which Professor Riley made during the summer of 1872 showed that the lathed canvas just mentioned secured on an average five times as many worms as any single Wier trap, and the rag, paper, and hay bandages all much more than any single Wier trap. A crucial experiment was tried by Dr. LeBaron, who, on each of four trees, put two of the Wier traps on opposite sides of the tree, one higher than the other, so as to admit of a carpet band between them. The result was:

Number of worms in upper traps	36
Number of worms in lower traps	44
Number of worms in cloth bands	188

The relative advantage of cloth bands in different positions, and the desirability of having two bands on the same tree, is also shown by Dr. LeBaron in a five-tree experiment, which we condense into the following table. One band was placed from 1½ feet to 2 feet above the other:

Number of worms in upper bands	282
Number of worms in lower bands	350

In nearly every case the lowest bands contained the most, while bands which were placed on some of the largest limbs captured very few after the middle of August, although quite a number in late July and early August.

There can be no question but that thorough use of trap bands will bring about admirable results, especially if neighbors unite. Professor Riley, in 1879, stated that he had no doubt but that the marked improvement in the Michigan apples noticeable at that time was due to the quite general use of bands in that State, brought about by the publications and lectures of a few enlightened men, and particularly by the discussions at the State Horticultural Society.

The larvæ captured under bands have been counted and tabulated, and the improvement in the character of the fruit has been noticed and recorded, but the only attempt with which we are familiar to ascertain and tabulate the exact proportion between the worms on a tree and those caught by the bands was that made by Mr. E. J. Wickson at the Agricultural Experiment Station at the University of California, during the summer of 1887. The results are given in Bulletin No. 75 of the Station, and indicate that while from a total of 457 apple and pear trees bandaged 2,704 apples and pears were found from which the worms had escaped, only 1,188 worms were collected from the bands, or 44 per cent. of the whole. The bands used were strips of old sacks, 5 or 6 inches wide, allowed to lap over well and tied with a string around the middle. It seems that but one band was allowed to each tree, presumably fastened at the middle of the trunk, and that they were examined once a week. The recorder states that he believes that many of the worms which issued from the apples and did not find their way to the bands were eaten by birds which were always working over the ground while he was in the orchard.

The others it was thought must have transformed under clods of earth, as there was no loose bark on the trees and no rubbish on the ground. Undoubtedly many, if not the majority, of those not found in the bands perished without transforming. Moreover, inasmuch as one worm often injures two adjoining apples or pears, the number of infested fruit is not necessarily indicative of the number of worms, although as occasionally more than one worm is found in a single apple, it is reasonably safe to assume that it is indicative. From what we know of the habits of the insect it seems that the latter happens less often than the former. Better results would also have doubtless been obtained had two bands been applied, one a foot or two from the ground and one near the crotch. However, just as it stands, 44 per cent. killed is a good showing, and as Mr. Wickson well says, "the destruction of this proportion of fully fed and healthy larvæ must be considered very satisfactory," and "it will be seen that the old method of treatment is still one of the most effective that can be employed."

The very thorough endeavors made by Dr. S. F. Chapin in California in 1882 are also interesting and deserve mention here. His results were admirable, but were only accomplished by the most careful and painstaking labor. Three methods were adopted. After July 10 he commenced a systematic examination of all fruit upon the apple and pear trees by means of a ladder, and every apple or pear found infested was picked and reserved for examination and destruction. Bands were placed upon 800 trees, and these were examined closely every week, and all larvæ found were counted and destroyed. All fallen fruit was immediately gathered and examined, and afterwards destroyed. So carefully was this done that at picking time the men were only able to discover about 200 infested fruit. His table is interesting on many accounts, and is reproduced:

Date.	Infested fruit picked from trees.	Infested fruit on ground.	Infested fruit at gathering.	Larvæ found in fruit from trees.	Larvæ in fruit on ground.	Larvæ in fruit at gathering.	Larvæ found in bands.	Cost of picking infested fruit and examination of bands.
1882.								
July 10, 12	211			60				$1.50
July 18							147	.60
July 20, 21	79			38				3.00
July 24							48	.60
July 31							46	.60
August 7, 9	119			35			26	3.50
August 12							14	.60
August 19, 21	100			63			27	2.60
August 28, 30	180			139			87	4.50
September 6, 9	481			308			498	5.30
September 15, 16	379			154			825	3.60
September 24							432	.60
September 26, 27	280			31				3.00
September 30							292	.60
October 14							94	.60
October 21							15	.60
October 28							1	.60
September 4		203			88			1.00
September 9		88			42			.50
September 15		60			22			.50
September 19		126			34			1.00
September 26, 27		36			4			
October 10		262						
October 21		255			55			.75
September 13			44			26		
October 10			156			28		
Total	1,829	1,030	200	838	195	54	2,552	36.90

Total infested fruit discovered, 3,059; total found, 3,639; total cost, $36.90.

SPRAYING THE TREES WITH ARSENICAL MIXTURES.—January 22, 1879, Mr. J. S. Woodward, of Lockport, N. Y., at the meeting of the Western New York Horticultural Society, held in Rochester, stated that, having sprayed certain of his apple trees with Paris green quite early in the season, just after the fruit had formed, to destroy the Canker-worm,* the trees thus treated bore perfectly sound fruit, whereas the rest of the orchard was badly infested by the Codling Moth (see Rural New Yorker, February 8, 1879).

This important statement was not further verified until the spring of 1880, when Prof. A. J. Cook, of Lansing, Mich., sprayed some Siberian crab-apple trees on the 25th of May, and again on the 20th of June, with London purple, 1 tablespoonful of the poison (London purple) to 2 gallons of water. The results, as published in the Proceedings of the American Association for the Advancement of Science for 1880, page 669, published in 1881, were admirable, and it was stated to be a perfect remedy, although no tabulated statements were given. Since 1880 Professor Cook has made many experiments with both Paris green and London purple, and does not hesitate to recommend spraying with either as almost a panacea. He recommends their use in the proportion of 1 pound of the poison to 100 gallons of water.

The remedy was at first received with some disfavor on account of the supposed danger in its use. The objections were summarized by Professor Riley in the Farmer's Review, during the fall of 1880, and in the American Entomologist for October, 1880 (Vol. III, No. 10, p. 244), but in these very articles he indicated his appreciation of the remedy, if it could be divorced from its seeming dangers. Later experience in fact has shown that where properly used the remedy is not at all dangerous. Analyses made of the calyces of a number of poisoned apples by Professor Kedzie at Professor Cook's request, in 1880, indicated this fact. A striking note, however, is published by Professor Forbes, to the effect that apples taken September 10 from a tree sprayed September 3, and analyzed by Professor McMurtrie, each yielded .9 milligram of arsenic, "an amount such that 74 apples would convey a poisonous dose." This would indicate that fall poisoning possesses some danger on account of the cumulative effects of arsenic.

Professor Cook has since published many articles on this subject, and seems to have met with the most perfect success in the application of this remedy. His perfect results and his broad and sweeping statements are not, however, perfectly borne out by the results obtained by other experimentors. For instance, compare the following statement made by Professor Cook in 1886 with the results obtained in Ohio, Illinois, and California, and which are described in the following pages, and it will be seen that while he deserves every credit for the part which he has taken in putting this truly valuable remedy before the public, he is probably not justified in giving the impression that it is an absolute specific, or that he was the first to demonstrate its value for the purpose:

"It will be remembered that six years ago at the Boston meeting of the Science Association, I demonstrated the value of the arsenites, Paris green and London purple, as specifics against the Codling Moth

* The first suggestion of Paris green for the Canker-worm, so far as we can learn, was made by Dr. LeBaron, in his Second Illinois Report, 1872 (for 1871), p. 116. The suggestion was adopted in Illinois as early as 1873, and the poison was used with good success (see Riley in Third Report U. S. Ent. Com., p. 192).—L. O. H.

(*Carpocapsa pomonella*, Linn.). Experiments each year since confirm all that was then said. It is a matter of surprise that one early application of these arsenites should be so effective, when we remember the natural history of the insect. But in this case, as ever, facts are too strong for theory, as I have shown for years. One application of the poison made in May, before the apples are larger than peas, in fact, almost as soon as the blossoms have well fallen, is often all-sufficient. This year I have two crab-apple trees adjacent. One was treated, the other not. Frequent and careful investigation has failed to find an affected apple in the one case, while in the other a large proportion of the fruit is destroyed.

"Two points should be urged regarding this remedy: (1) Do not delay the application till June, when the larvæ are far into the fruit, out of harm's way. Neglect of this caution explains why some even of our careful investigators have partially failed. The remedy should be applied just when it will also destroy the destructive leaf-rollers and the dreaded canker-worms. (2) We must use a weak mixture. One pound of the poison to 100 gallons of water is best; then we can make thorough work without injury to our trees. With a pound to even 50 gallons of water we are quite likely to destroy some of the foliage if we make a thorough application." (A. J. Cook, Proc. 7th Ann. Meeting Soc. Prom. Agr. Sci., Buffalo, N. Y., 1886.)

It is but fair to state that in the Illinois experiments by Forbes, now to be treated, the first recommendation urged by Cook, viz, that the application be not deferred until June, was not followed and the first application was made June 9, although the season was probably a late one, as Forbes states that when the spraying with Paris green was begun the apples were only as large as currants. It should also be stated that Forbes' Paris green solution was stronger than Cook's London purple solution, the former using 1½ ounces to 5 gallons water, and the latter 1 pound to 100 gallons,* with the result that in Forbes' experiments considerable damage was done to the foliage. Moreover, Forbes' experiments with London purple were not begun until June 13, four days after his first Paris green application, and his mixture was only a little more than two-thirds the strength of the Paris green solution, which, by the way, made it slightly weaker than the solution recommended by Cook. These facts, therefore, render his conclusions as to the value of London purple of little weight, while his conclusions concerning Paris green should be accepted only with the understanding that he injured the foliage by the strength of his mixture. Forbes' conclusions from his 1885 experiments are as follows:

"(2) Owing to the scarcity of apples and the abundance of apple insects, the season was the most unfavorable possible for the success of these remedies.

"(3) The insecticides were applied suspended in water, the Paris green in the ratio of 1½ ounces to 5 gallons, the London purple in half that weight.

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"(4) The spraying with Paris green began when the apples were about as large as currants, and four days later with the London purple.

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*The London purple used by Forbes contained 22.5 per cent. metallic arsenic and the Paris green 15.4 per cent.

"(5) All the trees were thoroughly sprayed seven and eight times between June 9 and September 3.

"(6) The fallen apples were gathered six times from July 16 onward, and those remaining were picked as they ripened.

"(7) All the apples, both fallen and ripened, 16,529 in number, were examined individually for insect injuries, and those due to the Codling Moth and Curculios were separately noted.

"(8) As a result of the examination of 2,418 apples from trees which had been sprayed with Paris green, and of 2,964 others from check trees which had not been so treated, it appeared at the end of the season that 21 per cent. of the poisoned apples had been infested by the Codling Moth and 67.8 of those not so treated; while 27.3 per cent. of the poisoned lot had been infested by the Curculios and 51.3 per cent. of those not sprayed. That is to say, treatment with Paris green had saved something more than two-thirds of the apples which would otherwise have been damaged by the Codling Moth, and something more than half of those which would have been sacrificed to the Curculio. It should be remembered in this connection that the Paris green not only serves to protect the apples from attack, but by actually destroying the insects must assist to lessen the amount of insect injury in succeeding years. Analysis of apples one week after treatment with Paris green, a heavy storm intervening, gave abundant evidence that this insecticide could not be safely applied for some weeks preceding the harvesting of the fruit.

"(9) As a result of the comparison of 1,205 apples from a single tree sprayed with London purple, and 2,036 apples from a check tree not so treated, it appeared that 49 per cent. of the former were affected by the Codling Moth and 58.8 of the latter, and also that 39 per cent. of the first lot of apples had been invaded by Curculios and 48 per cent. of the second lot. The London purple thus saved about one-sixth of the apples which would otherwise have been sacrificed to the Codling Moth and about one-fifth of those otherwise to be spoiled by the Curculios.

"In comparing these results with those derived from the Paris-green experiment it must be remembered, however, that the spraying with London purple began four days later than that with Paris green, and that the latter, as used, contained about one-third more arsenic than the former. It should be further noted that both were applied to the limit of considerable damage to the foliage conspicuous as early as the last of July.*

* * * * * * *

"(11) As bands or traps serve only to capture the apple worm after it has done its mischief, and hence only interpose a general protection against future attack, and are moreover liable to be rendered ineffectual by neglect of one's neighbors, the use of Paris green will serve at least as a valuable addition to remedial measures against the Codling Moth. Since it may be safely applied, however, only

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*Elsewhere (p. 37) in the same article, however, Professor Forbes says: "Late in the season some scorching of the leaves similar to that attributed to the Paris green was noticed on this London-purple tree; less serious, however, than in the other case." In addition to this modification of the statement, we may call attention to the fact that there was a considerable reduction in the time elapsing between the first and second applications of the purple, as compared with the first and second applications of the green, and this will have considerable weight in accounting for the scorching by what Cook recommends as a safe mixture.—L. O. H.

for the spring brood, it is best to use both bands and insecticides, each measure supplying the deficiencies of the other.

"(12) Attending only to the picked apples, and condensing our statement of results to the last extreme, we may say that, under the most favorable circumstances, Paris green will save to ripening, at a probable expense of 10 cents per tree, seven-tenths of the apples which must otherwise be conceded to the Codling Moth; that London purple will apparently save about one-fifth of them; and that lime will save none."

Professor Forbes' tables follow upon the ensuing pages.

During the season of 1885 Mr. E. S. Goff, the horticulturist of the New York agricultural experiment station at Geneva, sprayed 6 trees three times with a solution of 1 ounce of Paris green to 10 ounces of water. The applications were made on June 3, June 5, and June 17. A heavy rain upon June 5 probably destroyed the effect of the first application. A careful examination in August and October of over 9,000 apples from the 6 trees sprayed and from 4 unsprayed check trees indicated that the average per cent. of wormy fruit from the sprayed trees was 13⅓, while the average per cent. of wormy fruit from trees not sprayed was 35¼. His conclusion is that the percentage of wormy fruit from the trees sprayed with Paris green and water was about 22 per cent. less than from those not sprayed. In other words, at this rate 100 barrels of apples picked from the sprayed trees would have yielded 22 barrels more fruit free from worms than the same number from the unsprayed trees (see Fourth Annual Report of the New York Agricultural Experiment Station, Albany, 1886, pages 246 to 248).

Professor Forbes, in Bulletin No. 1, office of the State entomologist of Illinois, gives a record of experiments made in 1886 supplementary to those recorded in the following tables. He sums up his conclusions in the following words:

"The experiments above described seem to me to prove that at least 70 per cent. of the loss commonly suffered by the fruit-grower from the ravages of the codling moth or apple-worm may be prevented at a nominal expense, or, practically, in the long run, at no expense at all, by thoroughly applying Paris green in a spray with water once or twice in early spring, as soon as the fruit is fairly set, and not so late as the time when the growing apple turns downward on the stem."

Paris-green experiment 1.

[Trees 1, poisoned, and 2, check.]

Trees.	Fruit.	Sprayed.	Examined.	Total No. of apples.	Codling Moth. No.	Codling Moth. P. ct.	Curculios. No.	Curculios. P. ct.	Both.	Total insects. No.	Total insects. P. ct.	Undetermined injuries. No.	Undetermined injuries. P. ct.	Total injuries. No.	Total injuries. P. ct.	Uninjured. No.	Uninjured. P. ct.
1	Fallen	June 9, 20, 30	July 16	141	10	7.1	28	21.3	(*)	38	27.0	10	9.7	48	34.0	93	66.0
2	....do	....do	....do	244	130	53.2	12	10.5	(*)	142	58.2	35	34.3	177	72.5	67	27.5
1	....do	July 15	July 24	177	42	23.1	12	9.5	(*)	54	30.4	1	.8	55	30.5	122	68.9
2	....do	....do	....do	370	253	68.4	66	56.4	(*)	319	85.4	4	7.8	323	85.5	47	13.0
1	....do	July 30	July 31	56	8	14.3	12	25.0	(*)	20	36.3	1	2.7	21	38.1	35	63.6
2	....do	....do	....do	120	84	70.0	23	63.8	(*)	107	89.0	......	......	107	89.0	13	10.8
1	....do	August 5	August 7	93	20	21.5	27	36.9	(*)	47	50.5	4	8.7	51	54.8	42	45.1
2	....do	....do	....do	61	34	55.7	19	70.3	(*)	53	86.8	2	25.0	55	90.1	6	9.8
1	....do	August 27	August 27	168	57	33.9	48	43.2	(*)	105	62.5	2	3.1	107	63.6	61	36.3
2	....do	....do	....do	189	133	70.3	42	75.0	(*)	175	92.5	4	28.0	179	94.7	10	5.2
1	....do	September 3	September 3	30	14	46.6	3	18.9	(*)	17	56.6	3	23.0	20	66.6	10	33.3
2	....do	....do	....do	53	42	79.2	8	72.7	(*)	50	94.3	......	......	50	94.3	3	5.6
Total 1	....do			665	151	22.7	130	25.2	(*)	281	42.2	21	5.4	302	45.4	363	54.5
Total 2	....do			1,037	676	65.1	170	47.0	(*)	846	82.3	45	23.6	891	86.7	146	14.0
1	Picked	September 3	September 10	846	178	21.1	230	34.4	(*)	408	49.2	184	42.0	592	69.9	254	30.0
2	....do	....do	....do	783	591	75.4	147	76.5	(*)	738	94.2	19	42.2	757	96.6	26	33.0
Grand total 1				1,511	329	21.7	360	30.4	(*)	689	45.6	205	25.2	894	58.0	617	40.8
Grand total 2				1,820	1,267	69.6	317	57.3.	(*)	1,584	87.0	64	27.1	1,648	90.5	172	9.4

Paris-green experiment 2.

[Trees 3, poisoned, and 4, check.]

Trees.	Fruit.	Sprayed.	Examined.	Total No. of apples.	Codling Moth. No.	Codling Moth. P. ct.	Curculios. No.	Curculios. P. ct.	Both.	Total insects. No.	Total insects. P. ct.	Undetermined injuries. No.	Undetermined injuries. P. ct.	Total injuries. No.	Total injuries. P. ct.	Uninjured. No.	Uninjured. P. ct.
3	Fallen	June 13, 20, 30	July 16	73	6	8.2	11	16.4	(*)	17	23.2	10	17.8	27	36.9	46	63.0
4	....do	....do	....do	326	205	62.8	56	46.2	(*)	261	80.0	8	12.3	269	82.5	57	17.4
3	....do	July 15	July 24	114	31	27.2	15	18.0	(*)	46	40.3	......	......	46	40.3	68	59.6
4	....do	....do	....do	149	79	53.0	37	52.8	(*)	116	77.8	......	......	116	77.8	33	22.1
3	....do	July 30	July 31	74	9	12.1	17	26.1	(*)	26	35.1	......	......	26	35.1	48	64.8
4	....do	....do	....do	112	51	45.5	41	67.2	(*)	92	82.1	......	......	92	82.1	20	17.8
3	....do	August 5	August 7	48	7	14.5	8	19.5	(*)	15	31.2	1	3.0	16	33.3	32	66.6
4	....do	....do	....do	56	30	53.5	19	73.0	(*)	49	87.5	......	......	49	87.5	7	12.6
3	....do	August 27	August 27	267	52	19.4	56	26.0	(*)	1 8	40.4	7	4.4	115	43.0	152	56.9
4	....do	....do	....do	144	129	89.5	13	86.6	(*)	142	98.5	......	......	142	98.5	2	1.4

* Not separately reported.

Paris-green experiment 2—Continued.

Trees.	Fruit.	Sprayed.	Examined.	Total No. of apples.	Codling Moth.		Curculios.		Both.	Total insects.		Undetermined injuries.		Total injuries.		Uninjured.	
					No.	*P. ct.*	*No.*	*P. ct.*		*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*
3	Fallen	September 3	September 3	31	9	28.9	5	22.7	(*)	14	45.1	......	.....	14	45.1	17	54.8
4	....do	....do	....do	35	31	88.5	2	50.0	(*)	33	94.2	......	.....	33	94.2	2	5.7
Total 3	....do			607	114	18.7	112	22.6	(*)	226	37.2	18	4.7	244	40.1	363	59.8
Total 4	....do			822	525	63.6	168	56.5	(*)	693	84.3	8	6.2	701	85.2	121	14.7
3	Picked	September 3	September 10	301	66	21.9	70	23.2	11	125	41.1	18	10.2	143	47.5	158	52.4
4	....do	....do	....do	322	220	68.3	117	36.3	56	281	87.3	13	31.9	350	93.3	28	8.7
Grand total 3				908	180	19.8	182	22.9	11	351	39.8	36	6.4	387	42.5	521	57.3
Grand total 4				1,144	745	65.1	285	42.8	56	994	85.1	21	14.0	1,051	86.9	149	13.0
Grand total 1 and 3				2,418	509	21.0	542	27.3	11	1,042	43.9	241	17.6	1,280	52.9	1,138	47.0
Grand total 2 and 4				2,964	2,012	67.8	602	51.3	56	2,558	86.2	85	2.9	2,643	89.2	321	10.8

London-purple experiment.

[Trees 5, poisoned, and 6, check.]

Trees.	Fruit.	Sprayed.	Examined.	Total No. of apples.	Codling Moth No.	Codling Moth P. ct.	Curculios No.	Curculios P. ct.	Both.	Total insects No.	Total insects P. ct.	Undetermined injuries No.	Undetermined injuries P. ct.	Total injuries No.	Total injuries P. ct.	Uninjured No.	Uninjured P. ct.
5	Fallen	June 13, 20, 30	July 16	444	154	34.6	104	35.8	(*)	258	58.1	11	5.9	269	60.6	175	39.1
6	....do	....do	....do	927	486	52.4	197	44.6	(*)	683	73.5	2	.8	685	73.7	242	26.1
5	....do	July 15	July 24	165	82	49.6	34	40.9	(*)	116	70.3	2	4.0	118	71.5	47	28.4
6	....do	....do	....do	366	165	45.0	90	44.7	(*)	255	69.6	1	.9	256	69.9	110	30.0
5	....do	July 30	July 31	88	35	39.7	36	67.9	(*)	71	80.6	......	.....	71	80.6	17	19.3
6	....do	....do	....do	146	73	50.0	60	82.1	(*)	133	92.5	......	.....	133	92.5	13	9.0
5	....do	August 5	August 7	68	27	39.7	33	80.4	(*)	60	88.2	......	.....	60	88.2	8	11.5
6	....do	....do	....do	84	47	55.9	35	94.5	(*)	82	97.6	......	.....	82	97.6	2	2.3
5	....do	August 27	August 27	243	171	70.3	20	28.0	(*)	191	78.6	......	.....	191	78.6	52	21.4
6	....do	....do	....do	243	207	85.1	21	58.3	(*)	228	93.4	2	13.3	230	94.6	13	5.3
5	....do	September 3	September 3	40	26	65.0	3	21.4	(*)	29	72.5	1	9.0	30	75.0	10	25.0
6	....do	....do	....do	62	62	100.0	......	......	(*)	62	100.0	......	.....	62	10.0	......	.....
Total 5	....do			1,048	495	47.2	230	41.6	(*)	725	69.1	14	4.6	739	70.1	309	29.5
Total 6	....do			1,828	1,040	56.8	403	51.1	(*)	1,443	78.8	5	1.3	1,448	79.0	380	20.8
5	Picked	September 3	October 9	157	96	61.1	48	30.5	25	119	75.1	2	5.2	121	76.3	36	22.9
6	....do	....do	....do	208	158	75.9	79	37.9	54	183	87.9	6	2.4	189	90.8	19	9.1
Grand total 5				1,205	591	49.0	278	39.1	25	844	70.0	16	4.2	861	71.3	345	28.6
Grand total 6				2,036	1,198	58.8	482	48.3	54	1,626	79.7	11	2.9	1,637	80.4	399	19.6

* Not separately reported.

What with the general experience among practical apple-growers who had used them, and Prof. Cook's experiments, Prof. Riley had come to accept the safety and general efficacy of the arsenites, properly used, as preventive of apple worm attack, and, in fact, had in consequence suggested their probable value, properly used, as against Curculio attack, in his address before the American Horticultural Society at New Orleans in 1885. With a view of testing this point and of settling some others raised by Forbes' work, Professor Riley had planned an extensive series of experiments to be made, during the season of 1887, and he instructed our Ohio agent, Mr. Alwood, who was advantageously located on the grounds of the Ohio Experiment Station, at the beginning of the season to work in this direction. Unfortunately, however, the season proved unpropitious, nearly all the apples in the neighborhood "blighting" after setting, although they set very full, and Mr. Alwood was called away in early July to take part in another and more pressing investigation. We quote from Mr. Alwood's notes such passages as bear upon the experiments made:

"On May 17, when first spraying was done, the bloom had fallen and an abundance of fruit was set on the young trees. However, within a few days fully 75 per cent. of this blighted, except in a few instances. These instances were trees sprayed, and as the observations given will show, there was scarcely fruit enough in the orchard, outside of trees treated, to furnish material to compare with treated trees.

"The orchard is composed of about 130 trees just coming into bearing. Twelve of the best trees were selected for the work, thinking there was abundant material around them for comparison. Six were sprayed with London purple and six with Paris green, at the rate of 1 pound of poison to 50 gallons of water. They were sprayed twice—May 17 and June 13. At first spraying Curculios were already at work, and it did not seem that spraying stopped them. The Codling Moth had not yet been noticed, and their larvæ did not put in appearance until after June 1.

"On June 21 the fallen fruit was collected and examined for larvæ. At this date trees untreated were almost barren of fruit, it having fallen before attaining any size or larvæ were hatched.

"Fallen fruit, Paris green.....	Curculio larvæ, 213 apples. Codling Moth larvæ, 13 apples.
"Fallen fruit, London purple..	Curculio larvæ, 267 apples. Codling Moth larvæ, 9 apples.
"Fallen fruit, untreated	Curculio larvæ, 96 apples. Codling Moth larvæ, 42 apples.

"The small amount of fallen fruit has already been explained. Before the close of season there was scarcely an apple on unsprayed trees, while some of those treated ripened several bushels. (They were all small trees.)

"Second counting was made June 28.

"Fallen fruit, Paris green.....	Curculio larvæ, 98 apples. Codling Moth larvæ, 10 apples.
"Fallen fruit, London purple..	Curculio larvæ, 87 apples. Codling Moth larvæ, 9 apples.
"Fallen fruit, untreated trees.	Curculio larvæ, 4 apples. Codling Moth larvæ, 18 apples.

"At this date both species were about full grown and some were leaving the fruit.

"In no instance did I find two Codling Moth larvæ in the same fruit, but several times found it and Curculio larvæ together, in which case I counted it to both; several times found as many as six Curculio larvæ in same fruit.

"I had also planned a much more extensive set of experiments for the old orchard, but it set no fruit at all.

"I sprayed two orchards for farmers who were interested, one living 6 and the other 9 miles out in the country. These were so far out that close observations were impossible. I went to Mr. F. P. Dill's place, 9 miles out, on Saturday, May 14. The trees were but a few days past bloom and in fairly healthy condition. The Canker-worms which have infested this orchard for some years had already made their appearance in such numbers that they would soon have destroyed the foliage on fully one-half the trees. The orchard is an old one, part of the trees having been planted by one of the first settlers, and some of them are 30 to 40 feet high and 40 to 50 feet through the branches at the widest part. It contained about 250 trees. The spray apparatus used was the Nixon's Little Giant, with his small-size pump fitted with but one spray nozzle.

"On the first half of the orchard we used Paris green and on the other London purple, both mixed 1 pound to 75 gallons of water.

"Three men did the work, which allowed a change at the pump at frequent intervals, as the force required with this size pump to spray such large trees was more than one man could stand for any length of time. However, by changing about, the work was readily accomplished. The whole time occupied was a little over eight hours. Six pounds poison was used and 450 gallons of water.

"*Results.* Here, as at the university, the fruit nearly all blighted.

"The Canker-worms were destroyed, and what little fruit matured was quite free from Codling Moth.

"The other orchard sprayed was for A. J. Gantz, 6 miles out in the country.

"His is an old orchard containing about 200 trees; used London purple and Paris green as before.

"This orchard was fairly sprinkled with Canker-worms, both *pometaria* and *vernata* being present.

"The worms were destroyed and the trees made a good healthy season's growth, better than for years. The fruit was just setting at time of application and the trees matured about one-half crop, not blighting so badly as the others. I examined these several times and found only from 20 to 30 per cent. affected by Codling Moth, and the farmer said it was some of the best fruit he had grown for years.

"The largest orchard in the county is on an adjoining farm owned by Mr. Coe, and his fruit that did mature was almost worthless from effect of Codling Moth."

Mr. Alwood sent material to five different prominent growers throughout the State of Ohio, asking them to make experiments, but only one furnished a detailed report.

Mr. Alwood vouches for Mr. Cushman's reliability and states that he is a member of the American Pomological Society, American Horticultural Society, and Ohio Horticultural Society, and his report is so interesting that we publish it in full:

EUCLID, OHIO, *November* 14, 1887.

SIR: It gives me pleasure to make the following report concerning the use of Paris green and London purple for the Codling-moth worm in apples.

Spraying apparatus used was the Little Gem, manufactured by A. H. Nixon, Dayton, Ohio. Have had but little experience with atomizers, but think this one is very satisfactory. Eighteen apple trees were selected for the experiments. The trees are twenty years old, have borne for several years, and but few perfect specimens have ever been produced. The trees are vigorous, having a spread of 30 feet. Varieties are Baldwin, King of Tompkins County, and Talman.

On the 22d of May the first application was made. This was exactly one week from full bloom. The Baldwins were one-fourth inch in diameter.

The proportion of green and purple had been previously carefully weighed, so that I could mix them in the following strengths: 1 pound to 100 gallons, 1 pound to 75 gallons, and 1 pound to 50 gallons.

The tank and pump were placed on a wheelbarrow for convenience in moving. Ten feet of hose was used. The nozzle end was tied to the end of a pole for the purpose of carrying it into and over the trees. Father managed the hose while I worked the pump. It took about $2\frac{1}{2}$ gallons per tree and about five minutes to apply it.

The day was clear and a light breeze served to carry the mist through the trees. It settled on apples and leaves like a heavy dew. The following plot of trees will show the detail of the experiment:

Variety.	Paris green.		London purple.	
	First row.	Proportion.	Second row.	Proportion.
Baldwin	x1 x2 x3	1 lb. to 100 gals.	x x x	1 lb. to 100 gals.
King	x4 x5 x6	1 lb. to 75 gals.	x x x	1 lb. to 75 gals.
Talman	x7 x8 x9	1 lb. to 50 gals.	x x x	1 lb. to 50 gals.

First application May 22, seven days from full bloom; second application May 26.

The afternoon after the first application two light showers fell; on the evening of the 24th two more; one was quite heavy. These showers coming so soon after spraying made me fear they had washed out the poisons. On the 25th I found little mites of maggots, from one to three in each calyx. After this they seemed to grow less, until scarcely any could be found on the 4th of June. One tree was not sprayed and one only the first time. These are not included in the eighteen.

Tree not treated dropped all of its fruit, and I did not find one apple but what was wormy. The tree sprayed only once had a fair share of perfect fruit, but not as much as those receiving two doses.

The fruit from the eighteen trees, as near as we could judge, was about alike. Trees 1, 2, 3, receiving the weakest application, had as large a proportion of fair apples as 7, 8, 9, which received the strongest. No difference could be distinguished between the amount of fair fruit on the Paris-green row and that on the London-purple row. About three-quarters of the apples were free from worms.

The practical result of the spraying is about as follows:

40 bushels marketable apples, at 80 cents	$32.00
Poisons and their application	4.00
	28.00
Probable result if not sprayed, 40 bushels cider apples, at 15 cents	6.00

Very truly,

E. H. CUSHMAN.

Mr. W. B. ALWOOD,
Special Agent, Division of Entomology.

It is only recently that the arsenical poisons have been seriously considered in California, but during the summer of 1887 a number of experiments were made at Berkeley by Messrs. Wickson and Klee, and the results, as summarized in tabular form in Bulletin No. 78 of the Agricultural Experiment Station, University of California, we give below.

It will be noticed that very weak solutions of Paris green were used, the strongest being more than twice as weak as the solution used by Professor Forbes. The gain of 71 per cent. in sound apples, however, with no apparent damage to the foliage, must be considered as quite satisfactory, although all of the experiments were made upon too small a scale to furnish a basis for reliable deductions. A

peculiar feature of the test is that the stronger substance (London purple) is used in much smaller dilution than the weaker substance (Paris green), and it is a very strange result that the purple used in the proportion of 1 pound to 160 gallons water should badly injure the foliage in the case of the two varieties of pear experimented with, and slightly damage the apples, while in Michigan 1 pound to 100 gallons is recommended as perfectly safe for apples. The California varieties may have been peculiarly susceptible, or the climatic conditions of moisture and evaporation such as to render the trees more liable to damage than in Michigan. We can not find that Professor Cook indicates the proper time of day for spraying, but we have found in Washington that spraying on a warm, dry, sunshiny day will be more apt to produce injurious results than the opposite, or, in other words, the more rapid the dehydration the greater the effect upon the foliage. Professor Riley has also shown (see Bulletin 10, Div. of Ent., p. 13) that after each rain the poison takes a new effect upon the foliage, and the inference is plain that in a climate where the dews at night are heavy and the days dry and warm the effect of the poison will be greater. Moreover, the foliage is more rapid of growth and consequently tenderer in California than in our Northeastern States.

The white arsenic experiments recorded in the following tables are practically valueless on account of the small scale upon which they were tried. The inference is, as Mr. Wickson points out, that the worms were not on hand to be killed in the case where the stronger solution shows a percentage of loss while the weaker shows a percentage of gain.

Paris green (1 pound to 160 gallons of water).

Fruit.	Variety.	Date of application.	Apparent effects.	Worms in fruit and under bands. On treated tree.	Worms in fruit and under bands. On untreated tree.
Pear	Nouveau Poiteau	May 3 and 19	None	10	23
Pear	Nantais	May 3 and 19 and once later.	....do	4	4
Apple	Red Canada	May 3, 19, and June 1.	....do	4	35
Total				18	62
Gain, per cent				71	

Paris green (1 pound to 320 gallons of water).

Fruit.	Variety.	Date of application.	Apparent effects.	On treated tree.	On untreated tree.
Pear	Duchesse Précoce	May 3	None	3	8
Pear	Dr. Reeder	May 3 and 19	....do	1	27
Pear	Chaptal	May 3, 19, and June 1.	....do	6	1
Apple	Duchess Oldenburg	May 3 and 19	....do	0	1
Apple	Fameuse	May 3, 19, and June 1.	....do	9	4
Total				19	41
Gain, per cent				54	

Paris green (1 pound to 160 gallons of water, with 2 pounds of soap).

Fruit.	Variety.	Date of application.	Apparent effects.	On treated tree.	On untreated tree.
Pear	Beurre Gris d'hiver	May 3 and 19*	None	5	2
Apple	Wells' Sweet	May 3	....do	3	3
Apple	Duchesse Mignonne	May 3 and 19	....do	1	13
Total				9	18
Gain, per cent				50	

* Considerable settling in can.

London purple (1 *pound to* 160 *gallons of water*).

Fruit.	Variety.	Date of application.	Apparent effects.	Worms in fruit and under bands. On treated tree.	Worms in fruit and under bands. On untreated tree.
Pear	De Tongres *	May 3	Badly injured	13	21
Pear	St. Michael Archangel.	do	do	4	0
Apple	Disharoon	May 3, 19, and June 1.	Little damage	9	9
Apple	Yopps' Favorite	May 3, 19, and June 1†	do	5	7
Total				31	37
Gain, per cent				16$\frac{2}{9}$	

London purple (1 *pound to* 80 *gallons of water*).

Pear	Emile de Heyst	May 3, 17,† and June 1†	Fruit and foliage damaged.	19	6
Pear	Madam Treyve	May 3 and 18†	do	0	24
Pear	Augustus Dana	May 3	do	0	4
Apple	Seek no Further	May 3	Badly injured	16	51
Total				35	85
Gain, per cent				59	

White arsenic (1 *pound to* 320 *gallons of hot water*).

Pear	Callebasse Monstreuse.	May 3	Foliage little damaged.	4	3
Apple	Grimes' Golden Pippin.	May 3 and 19		1	0

White arsenic (1 *pound to* 480 *gallons of water*).

Pear	Ott	May 3	None	0	1
Apple	Early Joe	do	do	0	17

White arsenic (1 *pound to* 640 *gallons of water, with soap*).

Pear	Napoleon	May 3, 20, and June 1.	None	1	3
Apple	Hall	May 3, 19, and June 1.	do	0	(‡)

* Two and one-half gallons of wash used.
† Strength of second and third sprayings, 1 pound to 220 gallons water.
‡ No check.

In the Transactions of the Iowa Horticultural Society for 1882 (vol. 17) is printed a prize essay by Hon. J. N. Dixon, of Oskaloosa, who strongly recommends the use of a solution of white arsenic, 1 pound to 200 gallons of water, for the Codling Moth, Tent Caterpillar, the Canker-worm, and the Apple Bucculatrix. He states (inferentially) that he first applied this remedy in 1875, intending it only for Canker-worms, thus arriving at the result in the same way as did Mr. Woodward in 1878. The paper, as a whole, contains many errors and is not of great value, and we mention it simply as a matter of record. It will be noticed by comparison that in the California white arsenic experiments the foliage was slightly damaged with a solution of 1 pound of this substance to 320 gallons of water.

In a discussion printed in the Transactions of the Iowa Horticultural Society, 1876, p. 52, Mr. Dixon mentioned the fact that he tried

Paris green for the Canker-worm in 1875, and at the advice of John Smith, of Des Moines, who had tried it previously, he experimented successfully with white arsenic in 1876.

It was probably this application, according to his 1883 statement, which put him on the track of the efficacy of the arsenical mixture for the Codling Moth, but we have no contemporaneous printed evidence that he made this inference, though there is correspondence with Professor Riley that may throw light upon the matter when fully studied.

It may be gathered from what precedes that as yet the use of arsenical mixtures for the Codling Moth is in its infancy. In limited localities practical apple-growers are taking it up, and particularly during the season of 1887 we have seen communications in the agricultural and horticultural journals giving accounts of successful trials. These, however, have been almost entirely in New York, Ohio, Michigan, and Illinois. It has been proven to be the best remedy yet known, but further experiments are still needed to ascertain the best modifications of proportions according to climate, condition of weather, and time of day.

Apparatus for applying the arsenical Mixtures.—The question of a suitable apparatus for spraying one's fruit trees is an important one, but is not difficult of solution. Good results can be obtained with the simplest apparatus. Professor Riley, in his different publications, has repeatedly described pumps and appliances which will answer this purpose admirably. It is not a difficult matter to mount a strong double-acting force-pump firmly upon a tight barrel, to mount the latter upon a sled or cart, to attach the rubber hose to an extension pole, and to fasten a nozzle at tip; and yet, having done this, a serviceable apparatus is complete, and at small cost beyond the price of the pump. Such an apparatus was described in its minutest details and figured in all its parts in the report of the Entomologist, annual report of this Department for 1881–'82, again in the report for 1883, and again in Bulletin No. 10 of the Division of Entomology. In the fourth report of the U. S. Entomological Commission a large series of pumps available for this purpose is figured and described. The subject of nozzles is there taken up, as also in the other publications just mentioned. A very complete, if somewhat cumbersome, apparatus is figured at Plate V, Rep. Ent. U. S. Dept. Agr. for 1886. It is one which is in use in California for spraying orange orchards for the Fluted or Cottony Cushion-scale. Its special features are its large size, the pump supplying two extension poles, the hose-reel, and the portable ladders.

Several pumps, with all accessory apparatus adapted for just this kind of work, have recently been placed on the market. Messrs. Woodin & Little, of 509 Market street, San Francisco, have mounted a strong double-acting pump with air chamber and brass valves, manufactured in New York by the Goulds, upon a 30-gallon barrel, with sled, nozzles, bamboo extension pole, mixer, strainer, and hose, and sell the apparatus complete for from $30 to $35, according to the amount of hose needed. This outfit seems to be a good one, and it may be an economy for busy orchardists within easy reach of San Francisco to purchase it.

The second apparatus is that manufactured by A. H. Nixon, of Dayton, Ohio, and which is described on page 57 of Bulletin 10 of the Division of Entomology. It is made in three styles and sizes, varying in price from $15 to $55.

The Field Force Pump Company, of Lockport, N. Y., have also placed on sale a spraying outfit, consisting of a strong force-pump, 8 feet of discharge hose, spraying nozzle, couplings, and suction pipe, all ready to mount on a barrel. The price of this outfit is $10. They also have a spraying apparatus operated by horse-power.

SILK CULTURE—REPORT OF THE YEAR'S OPERATIONS.

MADE TO THE ENTOMOLOGIST.

By PHILIP WALKER, *Agent in charge.*

Plates VII and VIII.

DISTRIBUTION OF SILK-WORM EGGS.

The policy of the Department, set forth in the last annual report, to distribute only eggs of the large Milanese varieties, has been followed during the past year, and a supply of eggs of the same races has already been purchased for distribution the coming season. These eggs have, in general, given excellent results, many persons having produced at the rate of 120 pounds of fresh cocoons for each ounce of eggs put in incubation. The distribution of last year amounted to about 150 ounces of eggs, sent to about 360 applicants, inhabiting almost every State east of the Rocky Mountains. These eggs were distributed in quantities varying from one-quarter of an ounce to one ounce. A suitable hibernating box was constructed at the Department some two years ago, and in it we have been enabled to keep eggs up to the moment that silk-raisers were ready to begin the rearing, at which period the distributions usually take place.

With the Commissioner's authority and under your instructions I have visited the silk-fields of Europe during the summer, and among other establishments inspected the egg-producing stations of Signor Susani, in Italy, and M. Deydier, in France. A description of these institutions and their methods of work will prove of interest to silk-growers. The eggs from M. Deydier's establishment have been largely used in the United States and have given universal satisfaction.

EUROPEAN EGG-PRODUCERS.

After Pasteur made his discoveries, which resulted in the establishment of his system of microscopical selection in the production of Silk-worm eggs, Signor Susani, of Milan, was one of the first to put the process into operation on a commercial scale. He now has the largest establishment of this sort in the world, employing 3,000 hands during the coupling season and 750 for microscopical examination. His place is situated at Albiate, about 10 miles northeast of Milan, and is called the Cascina Pasteur. The building is about 100 feet wide by 120 feet long, the center of the ground floor being occupied by the hibernating room, which is so well described by Maillot* that his account of it is reproduced here:

> This room is 20 meters long by 5 wide and 4 high; its walls are double, the exterior one being 70 centimeters and the interior one 15 centimeters thick; the floor is

* Leçons Sur le Ver à Soie du Murier, p. 30.

formed by a layer of rubble, covered with hydraulic cement; the walls and floor are covered with asphalt. The ceiling, made of iron and brick, is covered with a layer of sand, over which is a floor, which in turn is covered with a large quantity of sawdust. To this ceiling are suspended three long boxes of galvanized iron, in which there circulates a concentrated solution of chloride of magnesium, which only freezes at — 20° C. This liquid is cooled by suitable refrigerating machines, and is carried from them in pipes to the boxes of the hibernating room. The air contained in this room is dried by masses of quicklime placed in wooden boxes; this air is renewed through openings in the doors and windows, and they are also careful to open for an instant a little before sunrise the windows which give on the surrounding rooms.

The refrigerating machine is one employing sulphurous acid after Pictet's method. The receptacle in which the liquid sulphurous acid is gassified is entirely plunged into brine, which is consequently cooled as the apparatus operates. This cold brine is forced by means of a pump into the troughs on the ceiling. At the same time another pump takes the sulphurous gas and liquefies it in a second receptacle, from which it is made to run from time to time into the first.

To assure the regularity of temperature in the cold room two Pictet machines are used alternately and prevent the suspension of work in case of accident to one.

This arrangement enables Signor Susani to safely hibernate large quantities of eggs, which amount sometimes to more than 60,000 ounces per year, though the capacity of the chamber reaches 100,000 ounces.

On each side of the hibernating room are the rooms occupied by the microscopists and their helpers. The division of labor in the preparation and examination of moths has here been carried to great perfection, the cells containing the eggs passing through the hands of three operatives before they reach the microscopist. The moths are carried to her already crushed in a small mortar, which occupies one compartment of a box, in the other division of which is placed the corresponding cell of eggs. Twenty of these boxes fill a tray, which serves to carry the stock through the different parts of the room while the moths are submitted to the various examinations. The microscopist then examines the twenty moths, one by one, placing tin tags bearing her number on the boxes of those which have shown corpuscles. The tray is then passed to the table of the "first comptroller."

At this table an attendant takes small portions of the liquids of each of the healthy moths and mixes them intimately in a small porcelain jar, the contents of which is examined by the comptroller. If he finds no traces of the pébrine after examining several slides from this lot, the jar containing the mixture is sent on to the second comptroller, who has portions of it mixed with like portions of the contents of several other jars, and submits the new mixture to another examination. If, on the other hand, the first comptroller has found disease in the mixture examined by him, the tray from which it was taken is sent back to the microscopist for further examination.

The cells passed by the second comptroller are then sent to a man who separates the pure eggs from the impure. In addition to the force of microscopists and their immediate helpers a large force of laborers, all girls and women, are occupied in the cleansing of the mortars and other apparatus used. The cells of unhealthy eggs are at once destroyed by fire, while those containing good ones are turned inside out and hung in the loft upon racks, under which sheets are laid to catch any eggs that may drop. The eggs are washed from the cloths later in the year when the microscopical work is terminated.

The advantages claimed for this system of "double control" are denied by many persons whose opinion on the matter is well worth consideration. Their objections to it are based on the following

reasoning: Suppose the extreme case of a tray containing twenty moths which have been pronounced healthy by the microscopist. If one of those moths were diseased it would be quite as possible as not to overlook the corpuscles which it contained in a mass of over a fluid ounce of the mixture, and once it is passed by the first comptroller the chance of its being discovered by the second is much smaller, as he takes but a small portion of the primary mixture and combines it with portions of others which might have been entirely healthy. Altogether they claim that the double control is but a step in an unworthy system of advertising.

At the Deydier establishment, which is situated at Aubenas, in the Department of the Ardêche, in France, this system of double control has been abandoned, the microscopists being divided into small groups, one operative supervising the accuracy of the work of the others of the group. The French establishment occupies an old filature building, and is not so completely fitted up as the Italian one. The production of eggs reaches about 15,000 ounces per annum. M. Deydier informed me that he had noticed that cocoons raised in the United States from his eggs were larger and better than those from which the eggs were originally produced in France. This, however, is not an unusual result of transplanting stock to a new climate.

MULBERRY TREES.

No effort has yet been made to rear Silk-worms on an extensive scale at the Department, because, though Osage Orange leaves may be easily obtained in any desired quantity, it has been impossible to find, in the immediate vicinity, a proper supply of Mulberry leaves with which to make comparative tests. A plantation, however, has been recently started in the Department grounds, which includes some of the best varieties, and it is hoped that we shall soon have a plentiful supply of food. Among other trees recently purchased are some from the Cattaneo nurseries, near Milan, where the care of the young trees is so systematic and well-conducted that an extended description of their methods will not be out of place here. Judging from our own experience it is not the custom of American nurserymen to in any way prune or train their Mulberry trees while in their plantation. As a result it is found to be almost impossible to train a two or three year old tree so that its foliage may be picked with the proper facility. The proper pruning and training of Mulberry trees is excessively important, as it is conceded upon all sides that three times as many leaves may be picked, in a given time, from a well-pruned tree as from one where nature has been allowed full sway. The methods employed in the Cattaneo nursery, while almost identical with those described in the tenth chapter of your manual on the Silk-worm, tend to show the care with which European nurserymen handle their stock from the seed up, so that a four-year-old tree, when sent from the nursery, is in just as good condition as if it had been raised on the silk-grower's own plantation.

THE CATTANEO NURSERIES.

The Cattaneo nurseries have their office in Milan and their plantations in the immediate vicinity. They make a specialty of a White Mulberry, which they call the "Primitive," the original stock of which they imported at great expense from China. It is, as far as can be

determined by casual examination, practically the same tree as the *japonica*, which has been largely planted in this country, and the advantages claimed for it are its rapid growth and large, nutritious leaves. The trees sold by the Cattaneo Company are all seedlings, and their manner of cultivation is as follows:

The seeds are planted in the month of June in little rills, and the first year they attain a height of about 2 feet. The spring of the second year they are transplanted and set out in quincunx, the rows being about 3 feet apart. The following spring they are cut down to the ground and one shoot only allowed to grow. This shoot attains a height of about 8 feet in one year, and has leaves as large as the two hands springing from its whole length. The fourth spring it is cut off to form the crown, at about 6 feet from the ground, and but three or four fine buds allowed to grow into branches, the rest of the stem being carefully kept free from suckers. The fifth spring it is ready for permanent planting and, in good ground, will furnish from 40 to 50 pounds of leaves the first year thereafter. Plate VII shows one of these trees eight years old from the seed and Plate VIII the same tree without its leaves. The tree from which these cuts were photographed was 26 feet high and 56 feet in circumference.

EXPERIMENTAL STATIONS.

It has been found necessary in European sericultural countries to constantly study the practical rearing of Silk-worms from a scientific point of view, so as to prevent the spread of false ideas and methods of work and eliminate such fallacies as may have found root in the minds of silk-growers. The Austrian Government first opened an experimental station for this purpose at Goritz, in 1870. The work of this station has been described in the report of the American minister at Vienna, which was printed in Vol. XII of the Consular Reports, page 262. The example thus set by Austria was soon followed by Italy in the establishment of a similar station at Padua, and by France, whose station is in connection with the University of Montpelier. All of these stations are in charge of men of great eminence in the science to which they have devoted their lives, Haberlandt being director of the Goritz station, Verson of that at Padua, and Maillot of the French institution. If the aims of the Department in establishing silk culture in the United States should be successful it will undoubtedly be necessary for our Government to follow the example thus set them in Europe, and it may therefore be of interest to publish an account of the station at Padua, as translated from a recent Italian work. It may be well to add that the Italian Government has also established upwards of sixty observatories in different parts of the Kingdom, which co-operate with the central station and become valuable means of collecting sericultural statistics, disseminating useful information, and aiding silk-raisers by the microscopical examination of eggs and other useful labors. Such observatories might ultimately be established in the United States in connection with the recently-organized agricultural experimental stations in the different States.

THE ROYAL SERICULTURAL EXPERIMENTAL STATION AT PADUA.

During the year 1870 the Austrian Government opened an experimental station at Goritz with a view to studying "the malady" of

the Silk-worm. Italy, where silk culture is one of the principal sources of wealth, was not long in following this example, and in the month of April, 1871, a royal decree established at Padua an institution called "The Experimental Sericultural Station." The Italian Government and the city and chamber of commerce of Padua pay the expenses of this institution. Its objects are:

(1) To study the raising of Silk-worms under the best conditions, and experiment with the products thereof.

(2) To study the feeding of Silk-worms both by means of physiological and chemical experiments.

(3) To study the causes of the diseases of Silk-worms and of the Mulberry.

(4) To produce and distribute healthy Silk-worm eggs and to examine eggs for silk-growers.

(5) To experiment with new varieties of eggs, as well as with all other articles which concern the magnanerie.

(6) To undertake all such studies and experiments as might be useful to sericulture.

(7) To distribute circulars and to deliver lectures so as to make generally known the best means of succeeding in silk culture.

(8) To give the greatest possible publicity to all matters connected with the sericultural industry in the Kingdom of Italy.

The governing body of the sericultural station consists of an administrative council, of which the director is a member, the members of the council hold office for three years, one-third of its membership going out of office each year.

The director is the chief of the institution, and his staff consists of a deputy and an assistant. It is their duty to do everything, either by study or by experiment, to advance the industry in the Kingdom.

Beside the building occupied by the station there is also a greenhouse for Mulberry trees, the leaves of which are employed in making advance educations, that is to say, educations before the usual season. There is also a small plantation containing a collection of the best varieties of Mulberry trees. Besides the magnanerie there is also a small filature of two basins used in testing the quality of cocoons.

The apparatus of the station consists of twenty microscopes, from several of the best makers, of plaster models, of maps, of incubators, etc., in a word, of all articles relating to silk culture.

Every month this station publishes a journal called "The Bulletin of Sericulture." (*Bulletino di Bachicoltura.*)

Every year there are two classes instructed; one of men, which lasts three months (April, May, and June), another of women (July and August). The station has done inestimable service for sericulture, it having granted diplomas to 250 pupils, who now occupy places in the sericultural observatories and spread their knowledge among silk-growers.

EXPERIMENTAL SILK FILATURE AT WASHINGTON.

The first reeling done in the experimental silk filature of the Department was during the week ending October 30, 1886. The consumption of the crop of the season of 1886 was terminated on August 13, 1887. During that period the work was not continuous, but was interrupted at various times and for various causes. In the nine and one-half months covered by the period mentioned, 1,057 pounds of

dry cocoons were consumed in the production of 263 pounds of reeled silk and 81¾ pounds of waste (*frisons*). Of these quantities, 556 pounds were cocoons of first quality and produced 143 pounds of reeled silk and 41 pounds of waste; and 501 pounds of second-grade cocoons produced 120 pounds of reeled silk and 40¾ pounds of waste.

We began the consumption of the crop of 1887 on the 15th of August, and have until the present time been principally occupied in the consumption of second-grade cocoons. It will be seen from the above figures that the rendition of the second-quality cocoons of 1886 averaged 4.271 pounds, or that 23.4 per cent. of the cocoons consumed were recovered in reeled silk and 8.1 per cent. in waste. It may be added that the limits of weekly rendition of these cocoons were 4.051 pounds, or 24.7 per cent., and 4.558 pounds, or 21.7 per cent. The second-grade cocoons of the crop of 1887 have given far better results than those of the previous crop, the average rendition having been 4.016 pounds of cocoons per pound of reeled silk, or 24.9 per cent., and the limits 3.895, or 25 per cent., and 4.152, or 24 per cent. The more uniform results obtained this year are due to the more thorough mixing of the cocoons of the various lots employed.

Very few first-grade cocoons of the crop of 1887 have been handled, but from those few we have been able to determine that the average results for the year will, with the first grade, as with the second, probably be better than were the best results for the previous crop. It will be possible to give figures substantiating this outlook only at the end of the year. It may, in general, be said that the cocoons received at the filature are better packed and show a greater degree of care on the part of the raisers than did those purchased a year ago.

PRODUCTION AND PURCHASE OF COCOONS.

The silk-growers of the United States are so few and are spread over so great an extent of country that it is impossible to collect any accurate statistics of the quantities of eggs which they incubate, or of the quantity of cocoons which they produce. The Department is therefore obliged to draw its conclusions as to the annual crop from the purchases made in the different filatures. The only purchasing stations of which the Department has any information are its own, at Washington; that of the Women's Silk Culture Association, at Philadelphia; that of the Kansas State Silk Station, at Peabody; and that of the State Board of Silk Culture, at San Francisco. The first two purchase from almost all the States east of the Rocky Mountains; the Kansas station from that State and the neighboring ones, and the California board from the Pacific slope. So far as they have been reported to us the purchases of dry cocoons have this year been as follows:

	Pounds.
Washington	2,213
Philadelphia	2,196
Peabody	1,765
Total purchases east of the Rocky Mountains	6,174

The purchases from the same area in 1886 were 5,115 pounds. The California board has not yet furnished us with statistics of its purchases.

As to the quality of the cocoons purchased this year we have already spoken. That they might have been better had they been stifled properly and in large quantities is also very apparent. The great importance of this systematic stifling has led us to give much thought to the matter and to try some experiments for the purpose of establishing the comparative value of our best American cocoons and of good cocoons of Italian production. For this purpose a quantity of Italian cocoons were imported this fall and the filature was occupied for a week in their consumption. The week before we had been employed in reeling a lot of first-grade American cocoons, well sorted, which had given us a weekly production of 13¾ pounds of silk, with a rendition of 3.557 pounds, or a recovery of 28.1 per cent. of silk. The Italian cocoons were, on the contrary, reeled just as they were received, without sorting, and while they gave a rendition of only 3.778 pounds, or 26.4 per cent., they gave a weekly production of 15½ pounds of silk. The cause of the lower rendition was due to the lack of sorting, and of the improved production to the fact that the Italian cocoons were all stifled together, while the American lot was made up of a number of smaller ones, stifled by different persons, with the use of different methods, operated at different degrees of temperature. The importance of all cocoons in a lot being uniformly stifled appears in the cooking of the cocoons, for it is necessary to cook an overstifled cocoon longer in order to soften its gum than it is to cook one stifled at the proper temperature. The result then is, in a mixed lot, that in order to cook the overstifled cocoons we boil the others to pieces and they give off too great a proportion of waste.

It is hoped that special arrangements may be made to purchase fresh cocoons this year, thus enabling silk-growers to dispose of their crops and to receive their money therefor about three months earlier than usual, and at the same time avoid the possible destruction of their cocoons through improper stifling or care. The advantage to be derived by the Department through systematic and regular stifling will be such as to enable us to offer 40 cents a pound for the best fresh cocoons, which is equivalent to at least $1.20 for dry cocoons, instead of $1.15, the highest price yet paid.

One of the chief burdens hitherto imposed upon silk-growers has been the onerous transportation rates charged on their shipments, which in many cases have eaten up the profits, which at the best were small. In our earnest desire to establish this industry in the United States we shall do all in our power to lessen this burden the coming season. To what extent we can aid silk-growers in this matter will be stated more fully in a circular to be issued later in the year.

The importance both to the silk-growers and silk-reelers of the success of this plan to purchase fresh cocoons can not be overestimated, and this success will largely depend on the quantity of fresh cocoons which are purchased. And further, the ability of the silk-grower to send in his crop during the limited period when fresh cocoons are purchased must depend upon the promptness with which he puts his Silk-worm eggs to hatch upon the appearance of the first buds upon the food plants from which he intends to nourish his worms. While, however, early raising is strongly urged upon all silk-growers, it must not be forgotten that there is always danger from late frosts, which may kill the leaves and deprive the young worms of their food.

One of the best lots of cocoons that we have received at the filature this year was sent in by a lady living in Johnson County, Mo. She writes us in regard to the expense of raising these cocoons as follows: "Twenty dollars would cover the expenses (excluding labor) for both years that I have been engaged in the work, or $10 for each year. This year I incubated 3½ ounces of eggs and raised 67¾ pounds of dry cocoons, for which the Department paid me $77.90. My mother and my four children assisted me in this work." It will be seen that the results obtained by this lady were but 58 pounds of fresh cocoons per ounce of eggs, whereas, as has already been stated, some of our correspondents have raised as much as 120 pounds, or more than twice as many. These results were, however, obtained with quarter-ounce lots and would have been reduced with larger educations.

CO-OPERATING ORGANIZATIONS.

In addition to the work already described as done at this Department, the State of Kansas has been experimenting under authority of an act passed in 1887, having established a station at Peabody, in Marion County. They have been very active in their work, both in operating a non-automatic filature of eight basins and in disseminating information in regard to the industry throughout the State. The Women's Silk Culture Association at Philadelphia is continuing the experiments in reeling silk under a Congressional appropriation, and the Ladies' Silk Culture Society of California, under a like subsidy, is organizing for the coming season. The State of California has also continued to support its sericultural board, which claims to be doing excellent work.

Altogether the interest in the industry seems to be much more active throughout the country than it was a year ago, and we may safely say that a very material progress has been made during the past year toward the establishment of silk culture in the United States.

We urge the importance to this work of the formation of clubs for mutual benefit. Not of associations destined to help in spreading silk-growing, nor to distribute material, but of combinations of neighbors who may help each other by their experience and by an interchange of ideas. They may unite in the hibernation and incubation of their eggs, one hibernating box and one incubator intelligently managed being sufficient for all the silk-growers in a town. The season's work done, they may, if they can not sell their cocoons while fresh, again unite in the use of the same stifling apparatus and in the transportation of the cocoons to market. In all these operations such combinations will save much expense and, if the work be well directed, will realize material results in the increased size of the crop and the enhanced price received for the cocoons. Such clubs would form centers of information in each section and ultimately serve as nuclei for organization in making the strength of the silk industry felt in the national and State legislatures. Should this advice result in the formation of such bodies, the Department will assist them in every way in its power.

REPORTS OF AGENTS.

REPORT ON THE GAS TREATMENT FOR SCALE-INSECTS.

By D. W. COQUILLETT, *Special Agent.*

LOS ANGELES, CAL., *January* 20, 1888.

SIR: I have the honor to transmit herewith my report upon the gas treatment for scale-insects (*Coccidæ*).

Shortly after my re-appointment last July as an agent of your division the supervisors of this county withdrew their offered reward of $1,000 for a perfect exterminator of the Icerya, and their reason for so doing is thus given by the Los Angeles Herald:

"On Saturday last the board of supervisors decided to rescind the reward of $1,000 which they had offered for the discovery of a remedy which would exterminate the White Scale Bug and other pests injurious to fruit trees. They came to this decision for the reason that it is believed that Mr. Coquillett, the Government appointee, has by his gas system mastered the problem which has so long been a puzzle to all fruit-growers."

My experiments have been conducted in the orange groves of Mr. J. W. Wolfskill, of this city. Both Mr Wolfskill and his foreman, Mr. Alexander Craw, have aided me much in my work, as has also Mr. W. G. McMullen, one of the members of the Los Angeles County Horticultural Commission.

Your own advice and frequent expressions of confidence have done much toward giving to my work whatever of merit it may possess.

Very respectfully,

D. W. COQUILLETT,
Special Agent.

Prof. C. V. RILEY,
U. S. Entomologist.

THE GAS TREATMENT FOR SCALE-INSECTS.

The process of destroying insects on plants in hot-houses by fumigating with sulphur, tobacco, and various other noxious substances, has long been in vogue, but up to a recent date this mode of warfare against insect pests has not been extended to trees and plants growing in the open air. The earliest record I possess of any attempt of this kind is a copy of the specifications for a patent (No. 64667) granted to Mr. James Hatch, of Lynn, Mass., on the 14th of May, 1867. The following extracts from these specifications will sufficiently explain the method pursued by Mr. Hatch:

"The invention relates particularly to the manner of effecting the destruction of insects known as Canker-worms, after their lodgment in trees and while consuming the foliage thereof. * * * I cover the entire head of the tree with a thin cloth of close texture, drawing the edges around the trunk, so as to envelope the branches in a sort of sack. Near the tree I have a furnace, over which is placed a pan containing tobacco, pepper, or other substances, the smoke from which will stupefy or kill the worms; and from this pan I lead a pipe directly into the sack. Applying heat to the pan by a lamp or by fuel introduced into the furnace, the smoke generated from the tobacco or other substance in the pan is thrown into the sack and soon fills it, coming into contact with all the leaves, and either killing or instantly dislodging every worm and all other insects that may be in the tree."

This method of destroying insects on trees could not have been very widely adopted. Dr. A. S. Packard, who for several years held the office of entomologist to the Massachusetts State Board of Agriculture, writes me that he is not aware that this method has been practiced in any part of the Atlantic States. I can find no reference to it, nor to any similar method having been used in any of the States east of the Rocky Mountains from the date of the Hatch patent up to the present time.

For several years past many attempts at destroying scale-insects with gases and fumes have been made in southern California. For this purpose the infested tree was inclosed in an air-tight tent the lower part of which was either fastened around the trunk of the tree or allowed to fall upon the ground; in the latter case a small

quantity of earth was thrown upon the lower part of it, to prevent the escape of the gas or smoke. The tent was then filled with the smoke or gas experimented with.

Among the first to make experiments of this kind were Messrs. J. W. Wolfskill and Alexander Craw, of Los Angeles; Mr. John Wheeler, of San Francisco; Hon. J. DeBarth Shorb, Col. J. R. Dobbins, and Mr. B. M. Lelong, of San Gabriel. The substance most commonly experimented with was the liquid bisulphide of carbon (CS_2), but this did not prove entirely satisfactory, owing to the time required for it to evaporate and become diffused in the tent.

Probably no person has spent more time and money in trying to discover some effectual method for destroying the scale-insects with gas than has Mr. J W. Wolfskill, of Los Angeles. In a paper read at a meeting of fruit-growers, held in this city on the 7th of October. 1887, Mr. Alexander Craw gave an account of the experiments made by Mr. Wolfskill and himself, from which we extract the following:

"Previous to the year 1884 we had only the Black Scale (*Lecanium oleæ*), to contend with in the Wolfskill orange groves, and these scales were easily kept in check by an application of whale-oil soap in the form of a spray; one application every two years was sufficient. In the fall of the year 1884 we found a few trees on the south side of the large grove infested with the Cottony Cushion-scale (*Icerya purchasi*); they became infested from an adjoining grove. We prepared for war, and soon had our spraying apparatus at work upon them. As we were in for extermination, we made a very strong solution of the whale-oil soap—so strong it almost defoliated the trees—and upon examination it looked as if we had gotten rid of the Icerya. A short time afterward, however, we found that the trees were again infested, and we sprayed again, using as much as 50 gallons of the solution to each tree; but even with all this care, some of the Icerya escaped and soon covered the trees again, spreading in a northeasterly direction through the grove. We then cut the trees back, letting the branches drop upon a large canvas and afterward burning them; we washed the stubs and trunks of the trees with the whale-oil soap solution, but even this severe treatment was not effective, so we concluded that spraying would not check this prolific creeping curse.

"Knowing the fatal effects of a high temperature upon the young of the Black Scale, Mr. Wolfskill suggested experimenting with heat; accordingly he had a tent constructed, and also a sheet-iron stove that would send the heat into the tent. We put the tent over an orange tree, and raised the temperature to 128° Fahrenheit for over an hour; this killed the Black Scales, but the Icerya seemed to enjoy the heat. The tree was injured, so we gave up dry heat. We next tried steam from a small steam-boiler; this cooked the top of the tree, but upon the lower half the Icerya were as lively as ever. Our next experiment was with tobacco smoke; this test lasted six hours, but had no effect upon the tree or scales. Sulphur fumes were also tried; this bleached the foliage, but did not harm the Icerya; a heavier charge killed both the tree and the scales. Among other experiments made under the tent were: Concussion from gunpowder; muriatic acid gas; carbonic acid gas; liquid chloroform, and also the gaseous chloroform manufactured under the tent from chloride of lime and methyl alcohol; arsenic, and other fumes and gases. We had very encouraging results from the liquid bisulphide of carbon; when confined for ten, twenty, or thirty minutes, or even for one hour, no satisfactory results were obtained, but when it was confined three hours it killed all of the scales, which soon assumed a pale buff color. The gas, being a very powerful solvent, also acted upon the eggs, and they were destroyed, while the trees were not injured; in fact, a few weeks afterward they started into a vigorous growth. Our efforts were then directed towards evaporating the bisulphide quickly; heat, steam-baths, agitation, circulating the air in the tent, exposing the bisulphide in shallow pans, and saturating sponges with it were tried, but without hurrying matters much.

"Prof. D. W. Coquillett was so well impressed with our method of treating trees that he decided to investigate the subject; accordingly, in the month of September, 1886, he began experimenting in the Wolfskill orange grove, and soon discovered that hydrocyanic acid gas would kill the scales and their eggs, but it also injured the foliage of the tree. We then united our efforts to remedy this evil, but it was something that required very close observation. We found that by withholding the water and allowing the sulphuric acid to come in contact with the dry cyanide of potassium in a fine stream we could treat trees without injuring even a blossom, while the gas proved fatal to the Black Scale (*Lecanium oleæ*), Red Scale (*Aspidiotus aurantii*), and the San José Scale (*Aspidiotus perniciosus*) confined in it ten minutes, but the Cottony Cushion-scale (*Icerya purchasi*) and eggs required a confinement of nearly thirty minutes.

"We then perfected an apparatus for putting the tent on tall trees quickly. This occupied a great deal of time, but we finally succeeded so well that we could change the tent from one tree to the other in less than two minutes. Mr. A. B. Chapman

and Mr. L. H. Titus, of San Gabriel, became impatient at the delay and requested Professor Hilgard, of the State University, to send them a chemist, and they would pay his expenses. In the month of April, 1887, Mr. F. W. Morse was delegated for this purpose, and he, too, finally discovered that hydrocyanic acid gas would kill the scales; but Professor Coquillett had made the same discovery over six months previously, so that the credit of this discovery belongs to this latter gentleman. Much credit is also due to Mr. J. W. Wolfskill for the great amount of time and money that he has devoted to this cause.

"ALEXANDER CRAW."

I am not aware that either of the other experimentors mentioned above have ever published the results of their experiments, nor have I been able to obtain any notes from them upon the subject.

Many years ago Dr. George Dimmock, one of the editors of Psyche, made a number of interesting experiments with pure gases on various insects, and his account of these experiments is given in the March-April number of that journal for 1877. The results obtained by him are briefly as follows:

"Carbonic acid gas (carbon dioxide) did not prove fatal to beetles confined in it for one or two moments, but several sow-bugs (*Oniscus*) confined in it from twenty to thirty minutes never recovered. Mixed with oxygen in the proportion of three parts of the former to one of the latter, it did not prove fatal to a beetle confined in it three minutes. When mixed in the proportion of sixty-six parts of the carbonic acid gas to thirty-four parts of oxygen, it did not prove fatal to a beetle confined in it five minutes, nor to a wire-worm (*Elateridæ*) confined in it thirty minutes, and of several sow-bugs (*Oniscus*) confined in it fifty minutes, to some it proved fatal while to others it did not.

"Carbonic oxide gas (carbon monoxide) did not prove fatal to beetles confined in it ten minutes, nor to butterflies confined in it thirty minutes.

"Hydrogen did not prove fatal to a beetle and butterfly confined in it five minutes.

"Oxygen did not prove fatal to a spider confined in it one hour, nor to a beetle confined in it for three days.

"Nitric oxide (NO) proved fatal to a beetle confined in it only fifteen seconds, while several sow-bugs (*Oniscus*) confined in it from forty to sixty seconds never recovered."

My own experiments with the nitric oxide mixed with air did not prove as successful as those made by Dr. Dimmock with the pure gas; in fact, the brown, fuming tetroxide proved more fatal to the Icerya than did the colorless oxids.

I first began experimenting with gases in the month of September, 1886, and have since continued it at intervals up to the present time; an account of these experiments will be found at the end of this report. Among the numerous gases tried none have given as good satisfaction as the hydrocyanic acid gas; an account of the discovery of the effects of this gas is given in the paper by Mr. Craw, reproduced above, and need not be repeated here. Several of the other gases experimented with by me have not as yet been given sufficient trial to justify me in reporting either for or against their use as insecticides.

In the month of April, 1887, several of the fruit-growers of San Gabriel, who had become acquainted with the results that Mr. Wolfskill, Mr. Craw, and myself had obtained with the hydrocyanic acid gas, applied to Prof. E. W. Hilgard, of the California State University, at Berkeley, for a chemist to assist them in experimenting with various gases, and he delegated Mr. F. W. Morse. Mr. Morse experimented with about half a dozen different kinds of gases, but found none so effectual as the hydrocyanic acid gas, which I had used over six months previously. His report will be found in Bulletin No. 15, Division of Entomology, of this Department. He was the first to use an apparatus for agitating the air in the tent, but this idea appears to have originated with Professor Hilgard, who writes me that he instructed Mr. Morse to always agitate the air in the tent after introducing the gas.

In the months of September and October, 1886, Mr. Albert Koebele, one of the entomological agents of this Department, made a few experiments with the liquid bisulphide of carbon, an account of which he gave in his report to Prof. C. V. Riley, published in the report of this Department for the year 1886, page 569. The results of these experiments, however, especially those made under a tent, are so discrepant as to leave one in doubt as to the value of the bisulphide as an insecticide.

During the past season I have made several experiments with the liquid bisulphide, the main object being to devise some method whereby it could be evaporated more quickly than by merely exposing it to the air, but the results of these experiments were not entirely satisfactory. I next manufactured the bisulphide by passing the vapors of sulphur over red-hot charcoal and conducting the gaseous bisulphide into the tent; but the numerous experiments I have made with the bisulphide

thus produced indicate that it can never be successfully used for the destruction of insects on trees.

THE TENT.

The tent used in inclosing the tree is of the usual circular form, with a conical or dome-shaped roof. It is usually made out of heavy bed-ticking, and is afterward thoroughly oiled with boiled linseed oil ; care should be exercised not to leave the tent folded or rolled up while still damp with the oil. A tent belonging to Mr. J. W. Wolfskill, of this city, had been recently oiled, and when nearly dry was rolled up and thrown upon the ground where the sun shone upon it ; this was in the forenoon, and when it was unrolled the next morning the greater part of it was found to be charred, as if by fire.

It would be desirable to use some kind of ready-prepared cloth for making the tent, but thus far no substitute for the oil-cloth has been found. I have received samples of water-proof cloth from the United States Water-proof Fiber Company, of New York, but even the heaviest grade, although evidently water-proof, is far from being air-tight. A sample of twilled sheeting, prepared especially for this purpose, is much closer in its texture than the above, but is not air-tight; they offer to furnish it at about 10 cents per yard, the heavy bed-ticking referred to above costing in Los Angeles about 19 cents per yard.

I have also received samples of rubber cloth manufactured by the Boston Rubber Company, of Boston, Mass. Their lightest and cheapest grade is a thin black cloth, which they offer to furnish and make into tents of any desired size, and with the seams closed up ; the price would be about 23 cents per yard. This grade might answer for small tents—those not more than 5 or 6 feet high—but it is not strong enough for large-sized tents. At my request the company manufactured a tent about 12 feet high from this grade of cloth, but found that it was not strong enough for the use I intended to make of it.

They also sent three other grades of rubber cloth manufactured by them, and costing from 50 to 65 cents per yard made into tents ; but it is doubtful that either of these grades would be strong enough for making large-sized tents.

I have also received samples of rubber cloth from the Goodyear Rubber Company, of San Francisco. Their light gossamer cloth is evidently not strong enough for making large-sized tents ; its price is about 60 cents per yard. Their black rubber sheeting is the best that I have seen for this purpose, but the price, 54 cents per yard, would doubtless prevent its being used for this purpose.

APPARATUS FOR OPERATING THE TENT.

Where small trees are to be operated upon a sheet might be used for the purpose of confining the gas ; or the sheet could first be sewed in the form of a sack, which could be easily slipped over a small tree from above, the operator standing on the ground, or upon a step-ladder. For operating on large trees, however, a device of some kind must be used for putting the tent on the tree, and also for removing it again.

The McMullen Tent.—This tent was originally devised by Mr. W. G. McMullen, of Los Angeles, and is designed for operating on trees not over 12 feet high. It consists of two upright wooden supports or legs, the upper ends of which are attached to the opposite sides of a circle made of round iron or steel rods ; this circle is intended to pass around the inside of the tent at the junction of the roof and sides, and is supported by iron braces passing to the wooden supports or legs. The rafters or supports of the roof of the tent are three in number, and their upper ends fit into holes bored into a circular block of hard wood, which is retained in its place by the weight of the tent ; the lower ends of two of these rafters are attached to the circle at the upper ends of the two braces on one side of the circle, while the lower end of the third rafter is attached to the circle at the upper end of the opposite wooden support, the three rafters thus forming a tripod. They should be perfectly straight instead of bowing outwardly.

The tent itself should be made several inches larger all around than the frame on which it is to be placed, to allow for shrinkage when oiled. For the purpose of holding the tent in its place on the frame, narrow strips of cloth may be sewed around the inside of the tent where the circle and rafters are to pass, the strips being wide enough to permit the circle and rafters to pass between them and the tent itself; or, what is still better, they may be sewed in the form of long tubes, through which the circle and rafters may afterward be passed.

On one side of the tent, midway between the two wooden supports, the tent itself is slit from the circle to the bottom of the tent, and a strip of cloth about 20 inches wide is sewed to the tent along either side of this opening, ex-

tending the entire length of the latter, the two strips to be sewed together at the top and for a distance of several inches down the side or front. Along the outer edge of each of these strips sew a wide seam, large enough to admit a piece of quarter-inch gas-pipe, which should be long enough to extend along the entire length of this opening in the tent. When these pieces of gas-pipe are in place, a strong piece of cord may be attached to each, near their lower ends, and passed through small pullies, fastened to the tent at the upper ends of the wooden supports or legs; by pulling down on these cords the door-way of the tent will be pulled wide open, so as to readily allow the tent to pass over the tree.

To accomplish this the two supports of the tent are lifted up by two persons and the tent is passed forward over the tree, after which the lower ends of the supports are allowed to sink into holes in the earth previously dug for this purpose, after which the holes should be filled up, the earth being packed quite firmly in them. The door-way of the tent is next closed by bringing its opposite sides together and wrapping the two pieces of gas-pipe, one around the other, fastening with strings sewed to the tent on either side of the door-way. The surplus cloth at the bottom of the tent is next spread out and earth thrown upon it to prevent the escape of the gas.

A tent of the above description has been used by myself and given very good satisfaction. I have recommended iron or steel rods for the frame of the tent, instead of gas-pipe, since the latter is very liable to break at the joints or couplings. There is yet need of a device of some kind by which the circle at the top of the tent could be made larger or smaller at the will of the operator, and also regulating the height of the wooden supports, so as to adapt the tent to the size of the different trees to be operated upon. The moving of the tent from tree to tree would be greatly facilitated if the wooden supports of the tent were attached to runners like those of a sled.

The Wolfskill Fumiga tor.—This apparatus was designed by Messrs. J. W. Wolf skill and Alexander Craw, of Los Angeles, and is the first that has been used with success upon the largest orange trees. A good idea of its appearance is given in Plate V.

This fumigator consists of a strong wooden frame mounted on a low wagon or truck; in the center is a tall mast, the bottom of which rests upon the wagon reach, which is strengthened by iron braces attached to the side pieces of the frame. The mast is placed between two pieces of pine timber and a stout iron pin passes through these pieces and through the mast. The bottom of the mast is kept in place by two blocks of hard wood bolted to the reach on either side of the mast; their inner ends are concave, so as nearly to encompass the lower end of the mast. For staying the mast four iron rods are attached at one end to the four corners of the frame on the wagon, while their upper ends are attached to an iron clamp which encircles the mast a little above the middle of the latter.

A short distance above this clamp is an arm or boom and its triangular brace, bolted together so as to encompass the mast; at either end of this arm is a frame carrying one main roller and two side rollers, the latter being placed at a distance of about 6 inches from either end of the main roller, and their office is to prevent the tent from passing off of the ends of the main roller while it is being drawn over the latter. For the support of these rollers and the triangular brace, iron rods are attached to the top of the mast and pass to either end of each of the roller frames, and also to each outer corner of the triangular brace, while two other iron rods are fastened at one end to each outer corner of this brace, their other ends being fastened to one of the wooden side pieces of the frame on the wagon. An iron rod also passes from each outer corner of the triangular brace to either end of the roller frame at the outer end of the arm to prevent side motion.

The tent is drawn off of the tree by means of a rope that passes through the two main rollers and down the mast to a windlass attached to the frame of the wagon, extending from one side piece to the other, and passing just behind the mast; by turning this windlass the tent is drawn off of the tree, passing over the main roller at the outer end of the arm, then over the one at the opposite end, and down the mast till the bottom of the tent has been elevated above the tops of the highest branches of the tree. At the bottom of the tent is fastened a circle of gas-pipe, for the purpose of keeping the bottom of the tent spread out while it is passing down over the tree; iron or steel rods made into a circle would be preferable to the gas-pipe, which is liable to break at the joints or couplings. To this circle are attached two or three ropes, to be used in pulling the tent down over the tree. The main rollers at either end of the arm are provided with a deeply-grooved pully in the center of each, over which the rope passes in drawing the tent off of the tree, or allowing it to pass down over one.

When it is desired to transport this fumigator to a considerable distance the mast is lowered by means of a derrick composed of four pieces of pine timber; the lower

ends of the foremost pieces are attached to the front corners of the frame on the wagon, while the ends of the other two pieces simply rest upon that frame on either side of the mast. The upper ends of these pieces are fastened together by a strong iron bolt, to which a large pulley is attached. In lowering the mast a large rope is attached to it just above the point where the iron clamp encircles it; the other end of the rope is then passed through the pulley at the upper end of the derrick, and from this point it passes to the windlass, upon which the rope is then wound. The block of wood bolted to the wagon reach in front of the mast is then removed, and the stay-rods fastened to the frame on the wagon are disconnected; then, by unwinding the windlass, the mast is lowered un il it rests horizontally upon the wagon, turning upon the iron pin that passes through the mast near its base.

I have used this fumigator repeatedly, and it has given good satisfaction when used on level ground and at a time when the wind was not blowing very hard. Two men can operate it with ease. For tran porting from place to place it is the best apparatus that has yet been produced. It is desired to have the stay-rods and windlass attached to a turn-table, so that the tent could be taken off of one tree and put upon another without moving the wagon; by this arrangement three tents could be operated by the one apparatus without any loss of time. It might also be desirable to mount this apparatus upon runners, like those of a sled, but placed as wide apart as the trees would admit.

This fumigator has not been patented up to date.

The Titus Fumigator.—This apparatus was devised by Mr. L. H. Titus, of San Gabriel, and is especially designed for operating on tall trees. It is shown in Plate IV, and consists of four corner posts made by bolting together two boards in such a manner that they form a right angle with each other; at the upper ends these posts are connected by cross-pieces formed of boards bolted together like those forming the corner posts. Two of these cross-pieces are longer than the other two, and are placed on opposite sides of the frame; they are connected near the middle by two cross-pieces, between which is placed the roller upon which the tent is to be wound when being drawn off the tree. These various cross-pieces are braced, as shown in Plate .

The lower end of each of the rear corner posts is rigidly attached to an axle, on the outer end of which a light wheel is placed, while the inner end is connected with the corner post by an oblique brace. The lower end of each of the front corner posts is attached to the middle of an axle having a light wheel at each end; the post is attached to the axle by an iron bolt, which permits the wheels to be at the same moment turned, the one forward and the other backward, like the forward wheels of a wagon or buggy. By means of this arrangement the fumigator can be turned about in a circle. The front and rear corner posts on each side of the fumigator are connected with each other by a cross-piece extending from one to the other, and strengthened by braces which extend obliquely from the cross-piece to the posts. When this fumigator is in use the front and rear cross-pieces shown in Plate IV as extending from the posts on the one side to those on the other are removed, so as to permit the frame to pass either forward or backward over the trees.

The top of the tent is attached by three ropes to the roller, while to the lower edge of the tent are attached four ropes, placed at equal distances from each other; each of these ropes passes through a pulley attached to a frame near each upper corner, and the end of the rope is attached to the lower edge of the tent at the place where the opposite end of the same rope is attached. For winding the tent upon the roller an endless rope is used; this passes around a grooved wheel at one end of the roller and is carried through a pulley near the upper end of one of the rear corner posts; from this point it passes to and around a grooved wheel fastened to the cross-piece near the lower end of this post, and this grooved wheel is operated by a crank.

In taking a tent off of a tree each of the corner ropes is pulled through its pulley, drawing the bottom of the tent upward, thus turning the tent inside out; after the tent has been drawn up as far as possible, the crank operating the grooved wheel that works the endless rope is turned, winding the tent upon the roller until it has been entirely removed from the tree. The fumigator is thus drawn forward until the tent is brought directly over the second tree, when the ropes attached to the lower edge of the tent are loosened, permitting the tent to drop down over the tree, at the same time unwinding the tent from the roller, and continuing this until the tent rests upon the tree.

I have helped to operate a fumigator of this kind several times, and it gave very good satisfaction, especially the manner in which the tent was let down over the tree and taken off again. The frame of the fumigator should be so constructed as to admit of its being lowered when not in use, to prevent its being injured by high winds; three of these fumigators have, to my knowledge, been totally wrecked by high winds within the last three months. There is also need of some device by which one of these apparatuses could operate two or three tents.

I am not aware that this fumigator has as yet been patented, although I am of the opinion that the inventor has applied for letters patent.

The Culver Fumigator.—This fumigator was devised by Mr. John P. Culver, of Los Angeles, who, on the 26th of July, 1887, obtained a patent on the same (No. 367134). While both the Wolfskill and the Titus fumigators allow the tent to pass down over the tree from *above*, the present one incloses the tree from one side, being made in the form of two half-tents, which encompass the tree and meet upon the opposite side. A very good idea of this fumigator can be gleaned from Plate VI.

The frame-work of the tent may be constructed either of wood or of band iron, and the covering may be a light grade of tin or a heavy grade of canvas or of bed-ticking well oiled with boiled linseed oil. The edges, which are to meet when the tent is closed, should be covered with a thick layer of felt.

The tent is transported from tree to tree upon a pair of runners, like those of a sled, fastened together by several cross-pieces, one of which is exactly in the middle, and near one end of this cross-piece is firmly attached an upright post, tall enough to reach a little above the lower edge of the roof of the tent; this post is further strengthened by two wooden braces attached to it near its upper end, their lower ends being attached to the runner on the opposite side of the sled. The two halves of the tent are attached to the post by means of four hinges, two of which are attached to the frame of the tent near its lower edge and not far from the juncture of the two halves, while the other two are attached to the frame near the lower edge of the roof. The opposite ends of these hinges are attached to upright rods fastened to the post near its upper and its lower ends, and are so arranged as to allow the tent to be raised or lowered, independent of the post; they are so constructed that when the tent is being closed it is pushed forward until it is entirely clear of the sled, so that when the tent is closed it can be dropped upon the ground. The raising and lowering of the tent is accomplished by means of a lever applied to the frame of the tent near the point where one of the lower hinges is attached.

In taking the tent off of the tree the tent is first raised up with the lever until its lower edge is above the upper side of the sled, after which the tent is opened and the two halves are swung around and allowed to rest upon the sled, as shown in Plate VI. The sled is then drawn forward until the junction of the two halves of the tent is brought opposite to the middle of the second tree, when the tent is slightly raised by the lever and the two halves swung around until they inclose the tree, after which they are fastened together and dropped upon the ground. The hinges at the upper end of the upright post on the sled are so constructed as to allow the tent to lean either backward or forward, so that its lower edge may conform to the surface of the ground.

I have been able to make only a single test with a fumigator of this kind, and it gave very good satisfaction. I am of the opinion that this fumigator will prove to be both cheaper and easier to operate than either of those described above. There is still need of some device by which the same tent could be made smaller or larger at the will of the operator, so that it may be made to conform to the size of the different trees. Mr. Culver, the inventor, informs me that he intends to use two of these fumigators, transmitting the gas from one tent to the other, but it is impossible at the present writing to say whether or not he will meet with success, as no tests of this kind have as yet been made. If successful, this method would reduce the cost of treating a tree at least one-half.*

THE GAS.

Among the numerous gases which I have tried none have given such good results as the hydrocyanic acid gas; even arseniureted hydrogen and sulphureted hydrogen, which are so fatal to the higher animals when respired, fail to produce the same deadly effects upon the scale-insects that is produced by the hydrocyanic acid gas.

The latter, when generated in the usual manner, by acting with sulphuric acid upon potassium cyanide dissolved in water, is very destructive to the foliage of the trees confined in it. To remedy this three methods are at present known, viz: The *dry cyanide* process, which consists of acting upon the dry potassium cyanide with sulphuric acid; the *dry gas* process, consisting of acting with sulphuric acid upon potassium cyanide dissolved in water and passing the gas through sulphuric acid; and the *cyanide and soda* process, which consists of mixing bicarbonate of soda with potassium cyanide dissolved in water and adding the mixture to sulphuric acid.

The dry Cyanide Process.—In my early experiments with this gas it was plainly

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*Mr. Coquillett writes later: "The tent of the Culver fumigator is now made without a frame-work, except the two arches; this makes it both cheaper and lighter than before, permitting the tent to more nearly conform to the shape of the different trees confined in it."—C. V. R.

to be seen that the less water the cyanide has been dissolved in the less injurious was the effect of the gas upon the tree confined in it. The heat generated in the production of the gas is sufficient to vaporize a considerable quantity of the water in which the cyanide has been dissolved, and this aqueous vapor collecting upon the leaves would condense the gas, which is very soluble in water, forming hydrocyanic acid, which is very destructive to plant life. It is also probable that the ascending vapor carried with it some of the unchanged cyanide solution, since it was clearly apparent that the gas was more injurious to the foliage when generated rapidly than when it was produced more slowly. Profiting by this discovery I next tried acting with the acid upon the dry, finely pulverized cyanide, and the result proved that the gas thus produced was less injurious to the foliage than when generated in the usual way. It still injured the leaves to a certain extent, due, as it appears, to the fact that the ascending gas carried with it some of the fine particles of the cyanide and lodged them upon the leaves. My next step was to use the cyanide in large pieces instead of pulverizing it, and the gas thus produced did not injure the tenderest leaves of orange trees, even when confined in it for an hour. The proportion of ingredients used was about two fluid ounces of sulphuric acid to each ounce of the potassium cyanide.

Muriatic acid may be used instead of the sulphuric, but it is not as strong, besides costing more. Only the best grade of the cyanide, such as that commonly used by photographers, can be used for this purpose, since the cold acid will not act upon the poorest grade, which is commonly used for mining purposes; and this remark is equally true in regard to both of the processes described below.

The dry Gas Process.—I have already alluded above to the fact that the drier the gas the less injurious was the effect upon the tree confined in it; and it occurred to me that the gas might be generated in the usual way, by acting with sulphuric acid upon potassium cyanide dissolved in water, and afterward be dried by passing it through some medium that would deprive it of its moisture. Knowing the great avidity of sulphuric acid for moisture, I determined to use it as a drier for the gas, and several tests which I have made with this gas dried in this way prove that it does not injure the foliage of orange trees confined in it, while it is just as fatal to the scale-insects as is the moist gas. The density of the acid through which the gas had passed was lowered about one degree, as indicated by the hydrometer; but this would not prevent its use for generating the gas.

The cyanide is dissolved by boiling in water for a few minutes, using 1 gallon of water for each 5 pounds of cyanide. It is desirable to use as little water as possible for this purpose, but the quantity could not be very much reduced from that given above ; I have tried to dissolve 5 pounds of the cyanide in half a gallon of water, but all of the cyanide had not dissolved after half an hour's boiling. For every ounce of the cyanide solution use half an ounce of sulphuric acid, but it is always desirable to add some of the acid to the prescribed dose, in order that there may be an excess of the acid. No evil results will follow if double the proper quantity of the acid were to be used, whereas if less than the proper quantity were used the whole of the gas would not be evolved from the cyanide solution ; hence the advisability of always using an excess of the acid.

In generating the gas the acid should flow upon the cyanide solution in a very fine stream. When they come in contact violent action at once takes place, and the gas is rapidly given off in the form of a dense whitish fog, resembling smoke and possessing a peculiar odor. When this gas, diluted with air, is inhaled, it produces a dryness in the mouth and throat.

It is impossible to give any definite rule for using the different ingredients that will apply to the differently sized trees, owing to the fact that trees of the same height may have a varying diameter of top; thus orange trees 12 feet tall may have a diameter of top ranging all the way from 6 to 10 feet. The manner in which the tree is pruned will also make a difference in the quantity of the ingredients to be used, some trees being allowed to branch almost from the ground, while others are trimmed up from 3 to 5 feet from the ground.

The following table, based upon numerous experiments which I have made on orange trees under a tent 10 feet tall and having a transverse diameter of 10 feet, will give a good idea of the proper quantities of each ingredient to be used in treating citrus trees :

Height (in feet).	Diameter (in feet).	Cyaniole solution (fluid ounces).	Sulphuric acid (fluid ounces).
6	5	2	1¼
10	10	12	7
12	8	9	5
16	12	28	16
20	14	47	26

This table is based upon the cubical contents of the space inclosed by the tent, supposing that the lower part of the tent rests upon the ground. No harm will result to the tree if twice the quantity that I have recommended be used, but of course, for the sake of economy, it will be desirable to use only such quantity of each ingredient as will be necessary for destroying the scale-insects infesting the tree to be treated with this gas. The sulphuric acid should have a density of 65° when tested with an acid hydrometer; should its density be lower than this, use an extra ounce of the acid for every five degrees of density below 65°.

The Cyaniole and Soda Process.—The third method of rendering the hydrocyanic acid gas harmless to the foliage of the trees confined in it consists o mixing this gas with carbonic acid gas, the latter having the property of extracting the moisture from the former, forming gaseous carbonic acid. This appears to occur only under a certain degree of pressure; thus, if the two gases are generated in the same open generator within the tent and allowed to rise and fill the tent, the hydrocyanic acid gas will prove nearly as injurious to the foliage of the tree confined in it as it would if no carbonic acid gas had been present.

The carbonic acid gas is produced by acting with sulphuric acid upon bicarbonate of soda or saleratus. The latter is first made into a thin paste with water, using about 1 fluid ounce of water to each 2 ounces by weight of the bicarbonate. Several seconds elapse after the sulphuric acid comes in contact with the soda paste before the evolution of the gas begins; a foamy mass soon appears, consisting of variously sized bubbles which rise up in the generator and finally burst, giving forth the colorless and odorless gas. A fluid ounce of the acid will evolve all of the gas from about 3 ounces of the bicarbonate, weighed before it is mixed with the water.

The bicarbonate has a tendency to settle to the bottom of the solution, forming a compact mass upon which the acid acts very slowly. On this account it is desirable to add the soda paste to the acid instead of following the usual method of adding the acid to the soda. I have used marble dust in place of the bicarbonate of soda, and the result obtained by its use was as satisfactory as when the bicarbonate had been used; it possesses none of the adhesiveness of the bicarbonate and consequently does not form a compact mass in the bottom of the solution.

The best results have been obtained when both the hydrocyanic acid gas and the carbonic acid gas were produced in the same apartment of the generator.

The cyaniole is first dissolved in water, as described above, using 5 pounds of the cyaniole to each gallon of water, and for every 10 fluid ounces of this solution use 9 ounces, by weight, of the bicarbonate. The bicarbonate is first made into a thin paste with water, as above described, after which it is added to the proper quantity of the cyaniole solution and thoroughly stirred; the whole is then added very slowly to the proper quantity of sulphuric acid, previously poured into the lower apartments of the generator.

The following table will give a good idea of the proper quantity of each ingredient to be used for the differently sized trees:

Height (in feet).	Diameter (in feet).	Cyaniole solution (fluid ounces).	Bicarbonate of soda (ounces by weight).	Sulphuric acid (fluid ounces).
6	5	2	$1\frac{4}{5}$	$1\frac{3}{4}$
10	10	12	11	11
12	8	9	8	8
16	12	28	27	25
20	14	47	43	40

The hydrocyanic acid gas will be just as effective if twice the amount of the bicarbonate of soda that I have recommended be used, together with a sufficient quantity of sulphuric acid to evolve all of the carbonic acid gas from it. This latter gas does not act as a diluent, as some persons have supposed, but simply as a drier, its sole office being to extract the moisture from the hydrocyanic acid gas, thus rendering the latter gas harmless to the foliage of the trees confined in it.

The carbonic acid gas does not injure the foliage of orange trees confined in it; when sufficiently pure, it stupefies the scale-insects confined in it for half an hour, but they wholly recover from the effects of the gas after the lapse of a few hours.

I noticed that when the trees were treated with the cyaniole and soda process in the hottest part of a very hot day the foliage was almost as severely injured as when the hydrocyanic acid gas had been used alone. We may conjecture that this results from the fact that at a high temperature the carbonic acid gas is freed from the aqueous vapor, leaving the latter in a proper condition for again uniting with

the hydrocyanic acid gas. When these two gases are reduced to the liquid state by pressure or by great cold, it is found that the liquid carbonic acid boils at a much lower temperature than the liquid hydrocyanic acid does. A given quantity of water will dissolve about its own volume of carbonic acid gas, but all of this gas thus may afterward be expelled by boiling.

Remarks.—Of the three processes described above, it is evident that the dry gas process is preferable to either of the others. Not only is there less labor in its manipulation, but it is also much cheaper than either of the other processes; this will readily appear from the following estimates of the cost of the material necessary for treating an orange tree 20 feet tall and having a diameter of top of 14 feet:

Dry cyaniole process.

24 ounces potassium cyaniole, at 5 cents per ounce	$1.20
52 fluid ounces sulphuric acid, at $1\frac{3}{13}$ cents per ounce	.64
Total	1.84

Dry gas process.

47 fluid ounces cyaniole solution, at $2\frac{1}{2}$ cents per ounce	$1.20
26 fluid ounces sulphuric acid, at $1\frac{3}{13}$ cents per ounce	.32
Total	1.52

Cyaniole and soda process.

47 fluid ounces cyaniole solution, at $2\frac{1}{2}$ cents per ounce	$1.20
43 ounces bicarbonate of soda, at $\frac{1}{2}$ cent per ounce	.21
40 fluid ounces sulphuric acid, at $1\frac{3}{13}$ cents per ounce	.49
Total	1.90

These prices are those current in Los Ang les when the various ingredients are purchased in small quantities at retail; when purchased in large quantities they could be obtained at a much lower rate. Mr. A. Scott Chapman, of San Gabriel, a member of the California State Board of Horticulture, informs me that he purchases the best grade of potassium cyaniole in large quantities at the rate of 50 cents per pound, and I have been shown a letter, addressed to Mr. J. W. Wolfskill, of this city, wherein a firm in Saint Louis, Mo., offered to furnish commercial sulphuric acid of the best grade at the rate of 2 cents per pound, net; the freightage on this acid from Saint Louis to Los Angeles would amount to about 5 cents per pound, making a total cost of 7 cents per pound for the acid delivered at Los Angeles. At these prices the cost of treating an orange tree 20 feet tall and 14 feet in diameter, by the dry gas process, would amount to about $1, not reckoning in the labor and interest on money expended for the apparatus.

After the tree has been confined in the gas the proper length of time the tent should be entirely removed from it. On two different occasions I simply opened the tent to allow the gas to escape, after which the tent was again placed on the tree and the doorway of the tent left partially open; it remained on one of the trees for seven consecutive days, while on the other tree it was allowed to remain only for a day and night, but in both instances the trees were nearly killed.

The generator used in the production of the hydrocyanic gas is as shown in the foreground in Plate V; it was originally devised by Mr. Alexander Craw and myself, and has given perfect satisfaction.

This generator consists of two leaden vessels placed one above the other and connected by a brass stop-cock; to the end of the valve of this stop-cock is firmly soldered an L-shaped piece of an iron rod, to be used in opening and closing the stop-cock. The lower vessel is entirely closed above; near one side of the top is a screw-cap, covering the opening through which the proper chemicals are to be introduced into the vessel, while on the opposite side is an opening over which is firmly soldered the end of a leaden pipe, through which the gas passes on its way from the generator to the tent. When it is intended to pass the gas through sulphuric acid this leaden pipe is made to enter one side of an upright leaden vessel, and as near the bottom of the vessel as possible; to the top of the leaden vessel is attached a tin or leaden pipe which conducts the dried gas into the tent. Of course, if it is not desired to pass

the gas through sulphuric acid the leaden acid-vessel can be dispensed with, the leaden pipe from the generator passing directly into the tent.*

In charging the generator for the dry gas process, the proper quantity of the potassium-cyanide solution is poured into the lower vessel through the opening closed by the screw-cap, this cap having first been removed, to be again replaced after the solution has been poured in. The stop-cock connecting the two vessels of the generator is next closed by turning the handle attached to the valve, after which the proper quantity of sulphuric acid is poured into the upper vessel. The tin pipe attached to the upper end of the leaden acid-vessel is then removed, and a slightly larger quantity of sulphuric acid is poured into this vessel than was poured into the upper vessel of the generator; there should be a sufficient quantity of the acid in this leaden vessel to slightly more than cover the end of the leaden pipe leading from the generator. The tin pipe is next attached to the upper end of the acid-vessel, as shown in Plate V, while the other end of this pipe passes into the tent previously placed over a tree and made ready for the reception of the gas.

When everything is ready the handle of the stop-cock of the generator is turned until the acid in the upper vessel commences to flow into the lower one, where it comes in contact with the cyanide solution, and the production of the gas begins. The acid should be allowed to flow very slowly upon the cyanide solution; if the gas is produced too rapidly the acid will be thrown out of the acid-vessel; the latter should be taller than indicated in Plate V, and it would doubtless be an advantage to have it wider at the top than at the bottom.

After all of the gas has passed into the tent, the acid in the acid-vessel should be emptied into a glass or leaden vessel to be used the next time for generating the gas; for this purpose it would be well to insert a brass stop-cock in the lower part of the acid-vessel. There should also be quite a large stop-cock in the lower part of the lower vessel of the generator, for drawing off the residue before again charging the generator with fresh materials. When not in use the two vessels of the generator, and also the acid-vessel, should contain a small quantity of water, which will prevent the valves of the stop-cocks from becoming so corroded that they can not be operated without first being taken apart and cleaned.

AGITATING THE AIR IN THE TENT.

After the gas has passed into the tent, and also while it is passing in, the air in the tent should be thoroughly agitated. The most effectual method of accomplishing this is by the use of some device whereby the air may be drawn out of the top of the tent and forced in at the bottom. When the McMullen or the Culver tent is used, the pipe taking the air out of the upper part of it can enter the top of the tent, but in the Wolfskill and the Titus tents both pipes must enter the tent at the bottom, the one intended for drawing the air out of the upper part of the tent passing some distance up the trunk of the tree, while the other pipe merely passes a short distance into the tent.

For circulating the air in the tent various devices have been used, but the one that has given the best satisfaction is known as the Cummin's blower, which was originally intended for forcing air into mines. It consists of an iron fan-wheel, driven with great velocity by means of a series of cog-wheels and pinions, the whole encased in an air-tight iron covering, having an opening on one side of the fan-wheel, through which the air is drawn out of the tent by means of a tin pipe, the base of which covers this opening. In the lower part of the fan-wheel chamber is a large opening, placed opposite to a similar opening in one side of an iron pipe closed at one end while to the other end is attached the tin pipe through which the air is to be forced into the tent. When the crank operating the fan-wheel is turned the air is drawn out of the tent through the tin pipe, and passes into the fan-wheel chamber through the hole in the side of the latter, and by the rapidly revolving fan-wheel is thrown by centrifugal force into the tent.

I had a blower constructed upon nearly the same principle as the above, except that the fans were made of tin, as was also the covering of the fan-wheel chamber, but it did not give very good satisfaction.

There is a machine manufactured at San José, Cal., and known as the Acme fumigator, which is provided with an iron fan-wheel driven by a belt. The blower

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*Mr. Coquillett writes later as follows: "In speaking of the gas generator I recommend passing the gas *through* sulphuric acid; a better way is to pass it *into* the acid, the leaden pipe which conducts the gas from the generator entering the upright leaden vessel above its middle, and curving downward in the vessel until the mouth of the pipe nearly reaches the bottom of the vessel and is covered by the acid."—C. V. R.

of this fumigator is much too small to be used for agitating the air in the tent, but the manufacturer, Mr. A. R. Tomkin, informs me that they could be made of almost any size, and that the price would be less than a third of that of the Cummin's blower. This is a very simple arrangement, and if made large enough would doubtless answer the purpose quite as well as the Cummin's blower, and at a much lower price.

It has also been suggested to use a common blacksmiths' bellows for the purpose of stirring the air in the tent, but it would appear to be a difficult task to manipulate it in such a way that the air would be drawn out of the tent as well as forced into it.

In the Culver tent a wooden fan is at present used, being placed inside of the tent as shown in Plate ; a fan of this kind, however, will always cause more or less trouble on account of its striking the branches of the tree inclosed by the tent. On this account it is advisable to always have the apparatus for agitating the air in the tent placed on the outside of the latter.

Whatever form of apparatus is used, it should be placed as near as possible to the point where the gas is to enter the tent; and if it can be so arranged that the gas can pass into the tent by the same pipe through which the air is forced into the tent, this will be a great advantage, since the gas will then become more thoroughly mixed with the air in the tent before reaching the foliage.

EXPERIMENTS.

Of the following experiments, those from 1 to 91, inclusive, were made upon small orange trees by covering them with a common five-gallon tin kerosene can, the upper end of which had been cut out, the gas being generated under the can after the latter had been placed over the trees. Experiments from 92 to 130, inclusive, were made by the use of a tent having a diameter of 10 feet; the height of the trees is given in the different experiments; the trees experimented upon were orange, except where otherwise stated. Measurements of liquid are given in fluid ounces and fractions of solids by avoirdupois weight.

(1) Diluted one part of commercial nitric acid with two parts of water. Took five-eighths of an ounce by weight of brass filings and one-half fluid ounce of the diluted acid. Confined it ten minutes. Thirty minutes later some of the Iceryæ were crawling about; three days later all of the leaves were dead, while nearly all of the Iceryæ were alive.

In this, and also in experiments from 2 to 5, inclusive, no red fumes were given off when the acid came in contact with the brass filings; in each the residue was of a bluish color.

(2) Took five-eighths of an ounce of brass filings and 1¼ fluid ounces of the diluted nitric acid. Confined it twenty minutes. All of the leaves but only a few of the Iceryæ were killed.

(3) Took one-third ounce brass filings and 1¼ ounces of the diluted nitric acid. Confined it fifteen minutes. Result same as in the preceding experiment.

(4) Took one-sixth ounce brass filings and 1¼ ounces of the diluted nitric acid. Confined it fifteen minutes. About eleven-twelfths of the leaves were killed; Iceryæ scarcely affected.

(5) Took one-thirteenth ounce brass filings and 1 ounce of the diluted nitric acid. Confined it fifteen minutes. About three-fourths of the leaves but only a few of the Iceryæ were killed.

(6) Took one-fifth ounce brass filings and one-fourth fluid ounce of pure nitric acid. Confined it ten minutes. About three-fourths of the leaves were killed; Iceryæ scarcely affected.

In this and the three following experiments dense brownish fumes were given off the moment the acid came in contact with the brass filings, and the residue was of a bluish-green color.

(7) Took one-fifth ounce brass filings and one-third ounce pure nitric acid. Confined it fifteen minutes. All of the leaves and about one-half of the Iceryæ were killed.

(8) Same as 7. Result the same; the dead Iceryæ were mostly situated on the upper part of the tree.

(9) Took one-eighth ounce brass filings and one-third ounce pure nitric acid. Confined it twenty minutes. All of the leaves and about one-half of the Iceryæ were killed.

(10) Took one-fourth ounce Paris green and one-half ounce pure nitric acid. Confined it fifteen minutes. Neither the leaves nor the Iceryæ were affected; the latter were as lively as ever a few minutes after removing the tin can.

(11) Took one-sixth ounce brass turnings and two-thirds ounce pure nitric acid.

Confined it fifteen minutes. All of the leaves and about nine-tenths of the Iceryæ were killed.

(12) Took one-twelfth ounce brass turnings and one-third ounce pure nitric acid. Confined twenty-five minutes. All the leaves and four-fifths of the Iceryæ were killed.

The skins of the dead Iceryæ in this and the preceding experiments soon became very dark colored and soft, readily breaking.

(13) Took one-fifth ounce brass filings and one-half ounce pure nitric acid. Confined it twenty-five minutes. All the leaves were killed and all the Iceryæ on the upper part of the tree, but scarcely one-half of those on the lower part were killed.

Whenever the brass filings were used, the leaves showed the destructive effects of the gas much sooner than when the turnings were used.

(14) Took one-sixth ounce pure zinc and five-sixth ounce pure nitric acid. Confined it twenty-nine minutes. Residue colorless. All of the leaves were killed and about one-half of the Iceryæ on upper part of tree, but only one-fourth of those on the lower part were killed.

(15) Dissolved one-half ounce of arsenic in 2 ounces of water in which one-half an ounce of caustic soda had been dissolved. Took 2½ ounces of water and two-fifths of an ounce of the arsenic-soda solution. Confined it twenty minutes. Leaves uninjured; about one-third of the Iceryæ were killed.

(16) Took 2½ ounces of water and 1 ounce of the arsenic-soda solution. Confined it twenty minutes. Leaves uninjured; very few of the Iceryæ were killed.

(17) Took 1 ounce of mercury and 1 ounce pure nitric acid. Confined it twenty minutes. One-tenth of the leaves and nearly all of the Iceryæ were killed. Residue colorless, but becoming bluish upon adding water to it.

I can not account for the good results obtained in this experiment. I have frequently tried to repeat it, but always without success.

(18) Took one-half an ounce of mercury and 1½ ounces pure nitric acid. Confined it twenty minutes. Leaves scarcely affected; about one-fourth of the Iceryæ were killed.

(19) Took one-eighth ounce pure tin in small pieces and 1 ounce pure nitric acid. Confined it twenty minutes. Residue nearly milk-white. Leaves uninjured; about one-fifth of the Iceryæ were killed.

(20) Took one-eighth ounce tin and 2 ounces nitric acid. Leaves uninjured; no Iceryæ killed.

(21) Took one-half ounce of mercury and 1½ ounces nitric acid. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(22) Took three-fourths ounce mercury and two-thirds ounce nitric acid. Confined it twenty minutes. Nearly all the leaves but none of the Iceryæ were killed.

(23) Took one-twelfth ounce pure copper in small pieces and 1½ ounces nitric acid. Confined it twenty minutes. Residue deep blue. All of the leaves and about one-sixth of the Iceryæ were killed.

(24) Took 3½ ounces of water and 1½ ounces of the arsenic-soda solution of experiment 15. Confined it twenty minutes. Leaves scarcely injured; only a few of the Iceryæ were killed.

(25) Put 1 ounce of sal ammoniac in 3 ounces of water; all of the sal ammoniac had not dissolved after the lapse of several hours. Took 2 ounces of this solution and added it to three-fourths of an ounce of quicklime. Confined it twenty minutes. All of the leaves but none of the Iceryæ were killed.

(26) Took an ounce of the sal ammoniac solution and added it to one-half an ounce of quicklime. Confined it twenty minutes. All of the leaves but none of the Iceryæ were killed.

(27) Took one-sixth of an ounce of naphthaline and 1½ ounces nitric acid. Confined it twenty minutes. One-third of the leaves but none of the Iceryæ were killed.

(28) To residue of above was added half an ounce of quicklime. Confined it twenty minutes. One-tenth of the leaves and one-half of the Iceryæ were killed.

(29) Took half an ounce of mercuric chloride and 1½ ounces nitric acid. Confined it twenty minutes. Leaves uninjured; about one-fourth of the Iceryæ were killed.

(30) To residue of above was added one-half an ounce of quicklime. Confined it twenty minutes. One-third of the leaves and one-fourth of the Iceryæ were killed.

(31) Took one-sixth ounce mercuric chloride and 1 ounce of nitric acid; added one-half an ounce of quicklime. Confined it twenty minutes. One-fourth of the leaves were killed; Iceryæ uninjured.

(32) Took one-fourth ounce of mercurious ointment, composed of lard and mercury, and three-fourths ounce of nitric acid. Confined it twenty minutes. Leaves uninjured; only a few Iceryæ were killed.

(33) To above residue was added three-fourths of an ounce of quicklime. Confined it twenty minutes. No leaves and but few Iceryæ were killed.

(34) Took one-third ounce of arsenic and 1½ ounces of nitric acid. Confined it twenty minutes. Residue greenish. A few leaves at the top of the tree and a few of the Iceryæ were killed.

(35) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. All of the leaves and about one-sixth of the Iceryæ were killed.

(36) Put half an ounce of arsenic in 2 ounces of water, and allowed it to stand for several hours. Added three-fourths of an ounce of quicklime to 1½ ounces of this arsenic solution. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(37) Took one-fiftieth of an ounce of strychnine and 1½ ounces of nitric acid. Confined it twenty minutes. Residue consisted of a brownish cloud in bottom of generator beneath the limpid liquid. No leaves and only a few Iceryæ were killed.

(38) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. Liquid portion of residue brownish; the solid portion bright yellow. No leaves and only a few Iceryæ were killed.

(39) Put about one one-hundred-and-sixtieth of an ounce of strychnine into half an ounce of water and added this to three-fourths of an ounce of quicklime. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(40) Took 1 ounce of mercury, stirred into it a little earth, and added 1 fluid ounce of nitric acid. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(41) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. One-half of the leaves, three-fourths of the Iceryæ on upper part, and one-fourth of those on the lower part of the tree were killed.

(42) Dissolved one-sixth of an ounce of arsenic in 2 ounces of muriatic acid. Took 1¼ ounces of this solution and one-sixth of an ounce of pure zinc in small pieces. Confined it twenty minutes. No leaves and only a few Iceryæ were killed.

(43) Added half an ounce of nitric acid to the remnant of the arsenic solution of the preceding experiment, and added this to half an ounce of pure zinc. Confined it twenty minutes. Nine-tenths of the leaves and forty-nine fiftieths of the Icerayæ were killed.

(44) Took 1 ounce, by weight, of mercury and 1 fluid ounce of nitric acid. Confined it twenty minutes. One-fourth of the leaves but only a few of the Iceryæ were killed.

(45) Dissolved one-sixth of an ounce of arsenic in 2 ounces of muriatic acid, and added half an ounce of nitric acid. Took 1 ounce of this solution and one-sixth of an ounce of zinc. Confined it twenty minutes. No leaves and only a few Iceryæ were killed.

(46) To residue of above was added three-fourths of an ounce quicklime. Confined it twenty minutes. A few leaves at the top of the tree were killed; about twenty-nine-thirtieths of the Iceryæ on upper three-fourths of the tree and two-thirds of those on the lower fourth were killed.

(47) Took half an ounce of the arsenic solution of experiment 45 and one-twelfth of an ounce of pure zinc. Confined it twenty minutes. Leaves uninjured; one-third of the Iceryæ were killed.

(48) Added one-fourth of an ounce of nitric acid to three-fourths of an ounce of the arsenic solution of experiment 45, and added this to one-sixth of an ounce of pure copper in small pieces. Confined it twenty minutes. Leaves uninjured; one-third of the Iceryæ were killed.

(49) Took 2 ounces of mercury and 1 ounce of nitric acid. Confined it twenty minutes. All of the leaves and about one-third of the Iceryæ were killed.

(50) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. A few leaves at top of tree and about two-thirds of the Iceryæ were killed.

(51) Took 1 ounce of mercury and three-fourths of an ounce of nitric acid. Confined it twenty minutes. One-half of the leaves and one-third of the Iceryæ were killed.

(52) Diluted one-fourth of an ounce, by weight, of bromine with 1½ fluid ounces of water, and added this to 2 pieces of phosphorus, each as large as a copper cent. Confined it twenty minutes. All of the leaves and one-third of the Iceryæ were killed.

(53) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. Leaves uninjured; one-fifth of the Iceryæ were killed.

(54) Diluted one-eighth of an ounce of bromine with 1½ ounces of water, and added this to a piece of phosphorus the size of a copper cent. Confined it twenty minutes. All of the leaves and one-fifth of the Iceryæ were killed.

(55) Dissolved one-third of an ounce of arsenic in 4 ounces of muriatic acid. Added 2 ounces of this solution to half an ounce of quicklime and one-sixth of an ounce of pure zinc in small pieces. Confined it twenty minutes. Liquid part of residue limpid, and upon this floated a dark-brown, ointment-like substance. One-third of the leaves were killed; found only one living Iceryæ.

(56) To 1 ounce of the arsenic solution of the preceding experiment was added half an ounce of nitric acid and 1 ounce of water; this was then added to one-fourh of an ounce of quicklime and one-sixth of an ounce of pure zinc. Confined it twenty minutes. Five-sixths of the leaves and two-thirds of the Iceryæ were killed.

(57) Added 1 ounce of nitric acid to 1½ ounces of the arsenic solution of experiment 55; this was then added to one-fourth of an ounce of quicklime and half an ounce of mercury. Confined it twenty minutes. Residue light brown. Only a few leaves and two-thirds of the Iceryæ were killed.

(58) Diluted 1 ounce of nitric acid with 1 ounce of water, and added this to one-fourth of an ounce of quicklime and one-fourth of an ounce of mercury. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(59) Put one-seventh of an ounce of naphthaline in 1 ounce of alcohol and let it stand for two days. Diluted half an ounce of this solution with 1 ounce of water, and added it to half an ounce of quicklime; upon adding the water to the colorless alcoholic solution the latter turned milky white. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(60) Dissolved half an ounce of arsenic in 6 ounces of muriatic acid. Added 2 ounces of this solution to half an ounce of quicklime. Confined it twenty minutes. One-sixth of the leaves and nineteen-twentieths of the Iceryæ were killed.

(61) Added 2 ounces of the arsenic solution of the preceding experiment to half an ounce of quicklime and half an ounce of mercury. Confined it twenty minutes. One-third of the leaves were killed; found only two living Iceryæ.

(62) Added 1 ounce of nitric acid to half an ounce of the naphthaline solution of experiment 59. Confined it twenty minutes. The residue was of a yellowish-green color, and had an oily appearance. All of the leaves were killed; found only one living Iceryæ.

(63) To the residue of the above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. One-sixth of the leaves were killed and a few of the Iceryæ.

(64) Same as in experiment 58. Leaves uninjured; only a few of the Iceryæ were killed.

(65) Added half an ounce of nitric acid to 1½ ounces of the arsenic solution of experiment 60, then added this to one-fourth of an ounce of quicklime and the same quantity of mercury. Confined it twenty minutes. Residue brown. One-fourth of the leaves and four-fifths of the Iceryæ were killed.

(66) Added five-sixths of an ounce of the arsenic solution of experiment 60 to half an ounce of quicklime. Confined it twenty minutes. No leaves were killed; found only two living Iceryæ.

(67) Added 1½ ounces of bleaching powder to 1 ounce of methyl alchohol. Confined it twenty minutes. One-eighth of the leaves were killed; nearly all of the Iceryæ on lower part of the tree but only a very few of those on the upper part were killed.

(68) To residue of above was added half an ounce of water and three-fourths of an ounce of quicklime. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(69) Added three-fourths of an ounce of nitric acid to 1 ounce of methyl alcohol. Confined it twenty minutes. Residue dark brown. No leaves nor Iceryæ were killed.

(70) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(71) Added three-fourths of an ounce of quicklime to 1 ounce of muriatic acid containing about one-fortieth of an ounce of the oil of tobacco. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(72) Added three-fourths of an ounce of quicklime to 1 ounce of water containing about one-fortieth of an ounce of the oil of tobacco. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(73) Added three-fourths of an ounce of nitric acid to half an ounce of water containing about one-fortieth of an ounce of the oil of tobacco. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(74) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(75) Mixed half an ounce of water with 1 ounce of carbon bisulphide, and added it to three-fourths of an ounce of quicklime. Confined it twenty minutes. Leaves uninjured; only a few Iceryæ were killed.

(76) Added three-fourths of an ounce of nitric acid to 1 ounce of carbon bisulphide. Confined it twenty minutes. Leaves uninjured; only a few of the Iceryæ were killed.

(77) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. One-eighth of the leaves were killed; found only one living Icerya.

(78) Added 1 ounce of muriatic acid to 1 ounce of carbon bisulphide. Confined it twenty minutes. Leaves uninjured; one-half of the Iceryæ were killed.

(79) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. One-half of the leaves on the lower half of the tree were killed; found no living Iceryæ on lower half of the tree, but found several on the upper half, nearly all of those at the very top of the tree being alive.

(80) Same as in experiment 78. Leaves uninjured; one-third of the Iceryæ were killed.

(81) Added residue of above to 1 ounce of quicklime. Confined it twenty minutes. One-half of the leaves on the lower half of the tree were killed; four-fifths of the Iceryæ on the lower half of the tree were killed, but only about one-half of those on the upper half.

(82) Added 1½ ounces of muriatic acid to half an ounce of potassium cyanide. Confined it twenty minutes. Residue of the color of claret wine. Leaves uninjured; found only 3 living Iceryæ.

(83) Added residue of above to 1 ounce of quicklime. Confined it twenty minutes. Liquid part of residue deep green, upon which floated a deep-blue substance. All the leaves on upper third of the tree were killed; found no living Iceryæ.

(84) Added 1½ ounces of water to half an ounce of potassium cyanide. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(85) Added residue of above to 1 ounce of quicklime. Confined it twenty minutes. No leaves and only a few Iceryæ were killed.

(86) Added three-fourths of an ounce of muriatic acid to one-half an ounce of chloroform. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(87) Added residue of above to 1 ounce of quicklime. Confined it twenty minutes. Leaves uninjured; nearly all of the Iceryæ on the lower third of the tree were killed, but nearly all of those on the upper third were alive.

(88) Diluted half an ounce of chloroform with the same quantity of water, and added it to 1 ounce of quicklime. Confined it twenty minutes. No leaves and only a few of the Iceryæ were killed.

(89) Added 1 ounce of muriatic acid to 1 ounce of benzine. Confined it twenty minutes. No leaves and only a few Iceryæ were killed.

(90) Added residue of above to 1 ounce of quicklime. Confined it twenty minutes. No leaves and only a few of the Iceryæ were killed.

(91) Diluted 1 ounce of benzine with half an ounce of water, and added it to 1 ounce of quicklime. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(92) Added 13 ounces of sulphuric acid (density 65°, as ascertained by the hydrometer) to 10 ounces of the best grade of fused potassium cyanide under the tent. Stirred air in tent five minutes with tin blower, then waited ten minutes, and again stirred it for five minutes. Left tent on tree from 3.30 to 4 o'clock p. m.; sun shining brightly. Tree 12 feet high by 10 feet in diameter; bottom of tent resting on ground. One-twelfth of the leaves and nineteen-twentieths of the Iceryæ were killed; fruit uninjured. A slightly larger percentage of the eggs hatched out than in the following experiment.

(93) Added 14 ounces of sulphuric acid to 10 ounces of potassium cyanide and 1 ounce of bicarbonate of soda. Stirred air in tent as before. Left tent on tree from 4.30 to 5 o'clock p. m.; sun shining brightly. A mandarin tree, 12 feet tall. Only a few leaves were killed; fruit uninjured. Forty-nine-fiftieths of the Iceryæ and nearly all of the eggs were killed.

(94) Dissolved 2 ounces of potassium cyanide in 3 pints and 1½ ounces of water. Added 13 ounces of sulphuric acid to 20 ounces of this solution. Stirred air in tent as before. Left tent on tree from 3 to 3.30 o'clock p. m.; sun shining brightly. Tree 12 feet tall. Two-fifths of the leaves, two-thirds of the fruit, and all of the Iceryæ and eggs were killed.

(95) Added 13 ounces of sulphuric acid to 20 ounces of the cyanide solution of the preceding experiment, in which had been stirred 1 ounce of bicarbonate of soda. Stirred air in tent as before. Left tent on tree from 3.50 to 4.20 o'clock p. m.; sun shining. Tree 12 feet tall. After treatment the tent was simply lifted up to allow the gas to escape, after which it was again placed over the tree, and the doorway left partially open; it remained over the tree for a whole week, when it was removed. Fourteen-fifteenths of the leaves, five-sixths of the fruit, and all of the Iceryæ and eggs were killed.

(96) Stirred 4 ounces of water into 11 ounces of bicarbonate of soda, and added it to 11½ ounces of the cyanide solution of experiment 94. To this were added 7½ ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 3.05 to 3.35 p. m.; sun shining. Tree 10 feet tall. One-fifteenth of the leaves, thirty-nine-fortieths of the Iceryæ, and nearly all of the eggs were killed.

(97) Poured 3 ounces of arsenic into 16 ounces of muriatic acid, and allowed it to stand a little over a week, then added it to 16 ounces of quicklime under the tent. Stirred air in tent as before. Left tent on tree from 4 to 4.30 p. m.; sun shining. Tree 10 feet tall. No leaves nor Iceryæ were killed.

(98) Stirred 7 ounces of water into 16 ounces of bicarbonate of soda, and added it to 15½ ounces of the cyanide solution of experiment 94; to this was added 11 ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 2.50 to 3.20 o'clock p. m.; sun shining. Tree 11 feet tall; a peach tree. Very few of the leaves and nearly all of the Iceryæ were killed.

(99) Boiled 20 ounces of arsenic and the same of bicarbonate of soda in 3 pints of water for one hour. Added 18 ounces of sulphuric acid to 24 ounces of the above solution. Stirred air in tent as before. Left tent on tree from 3.45 to 4.15 o'clock p. m.; sun shining. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(100) Stirred 6 ounces of water into 14½ ounces of bicarbonate of soda, and added it to 15½ ounces of the cyanide solution of experiment 94; to this was added 10 ounces of sulphuric acid. Did not stir the air in the tent. Left tent on tree from 3 to 3.30 o'clock p. m.; sun shining. Tree 11 feet tall. One-half of the leaves were killed; found no living Iceryæ.

(101) Stirred 24 ounces of water into 42 ounces of bicarbonate of soda; to this was added 11 ounces of sulphuric acid. Stirred air in tent for five minutes after starting, waited ten minutes and then stirred it again for five minutes. Left tent on tree from 3.55 to 4.25 o'clock p. m.; sun shining. Tree 11 feet tall. No leaves nor Iceryæ were killed; the latter were motionless when the tent was first removed from the tree.

(102) Stirred 12 ounces of water into 31 ounces of bicarbonate of soda, and added it to 15½ ounces of the cyanide solution of experiment 94; to this was added 12 ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 2.55 to 3.25 o'clock p. m.; sun shining. Tree 11 feet tall. Very few leaves were killed; found only three living Iceryæ.

(103) Stirred a sufficient quantity of water into 11 ounces of bicarbonate of soda to make it into a thin paste, and added it to 11½ ounces of the cyanide solution of experiment 94; to this was added 7½ ounces of sulphuric acid. Stirred air in tent only five minutes after starting. Left tent on tree from 3.10 to 3.40 o'clock p. m.; sun shining. Tree 10 feet tall. Two-thirds of the leaves, nearly all of the fruit, and all of the Iceryæ were killed.

(104) Stirred a little water into 1 pound of marble dust, and added it to 11½ ounces of the cyanide solution of experiment 94; to this was added 8 ounces of sulphuric acid. Stirred air in tent as in experiment 101. Left tent on tree from 4.05 to 4.35 p. m.; sun shining. Tree 10 feet tall. Only a few of the leaves were killed; found no living Iceryæ.

(105) Added 10 ounces of sulphuric acid to 16 ounces of the cyanide solution of experiment 94, and passed the gas through 24 ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 2.45 to 3.15 o'clock p. m.; sun shining. Tree 11 feet tall. Very few of the leaves, none of the fruit, and about forty-nine-fiftieths of the Iceryæ were killed. The density of the sulphuric acid before the gas passed through it was 64½°, as indicated by the hydrometer; after the gas had passed through it its density was found to be 63½°.

(106) Added 11 ounces of sulphuric acid to 16 ounces of the cyanide solution of experiment 94, and passed the gas through 24 ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 3.50 to 4.20 o'clock p. m.; sun shining. Tree 11 feet tall. Very few of the leaves and nearly all of the Iceryæ were killed. The acid through which the gas was passed had a density of 63½°, as indicated by the hydrometer.

(107) Added 16 ounces of sulphuric acid to 26 ounces of the cyanide solution of experiment 94, and passed the gas through sulphuric acid. Stirred air in tent as before. Left tent on tree from 3.40 to 4.10 o'clock; sun shining. Tree 11 feet tall. Leaves scarcely affected; found no living Iceryæ. The residue contained acid in great excess.

(108) Dissolved 5 pounds best grade of potassium cyanide in 6 pints of water. I first tried to dissolve it in 4 pints of water, but all of the cyanide was not dissolved after being boiled for 1 hour; I then added 2 pints of water, when all of the cyanide dissolved after being boiled for only a few minutes. Added 16 ounces of sulphuric acid to 30 ounces of the above cyanide solution, and passed the gas through sulphuric acid. Stirred air in tent as before. The tent had been charged with a small quantity of the gas, after which it was opened and allowed to remain on the tree from 11 o'clock a. m. to 10.30 o'clock a. m. of the following day, when it was charged and allowed to remain on the tree for half an hour longer. Tree 11 feet tall. Fourteen-fifteenths of the leaves were killed; found no living Iceryæ.

(109) Added 2 pounds of bicarbonate of soda, made into a thin paste with water, to 24 ounces of the cyanide solution of experiment 108; to this was added 20 ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 12.40 to 1.10 o'clock p. m.; sun shining. Tree 11 feet tall. One-sixth of the leaves were killed; found no living Iceryæ.

(110) Sublimed 1 pound of flowers of sulphur, and passed it into the tent. The sulphur was put into an iron vessel having a perforated lid, and this was set on the hot charcoal in the upright furnace of an Acme Fumigator; this fumigator is furnished with a fan-blower, to which I had a tin pipe attached in such a manner that the air was drawn out of the top of the tent and forced into the lower part of the upright furnace, passing by another pipe out of the upper part of the furnace into the lower part of the tent. The sulphur vapor was passed into the tent in fifteen minutes, after which the tent was removed from the tree. Tree 10 feet tall. Three-fifths of the leaves, all of the fruit, and four-fifths of the Iceryæ were killed.

(111) Sublimed half a pound of sulphur, as in the preceding experiment, and passed it through a second horizontal furnace, in the form of a cylinder, about 18 inches long and 6 inches in diameter, filled with red-hot charcoal. Passed it into the tent in ten minutes, and left tent on tree ten minutes longer. Tree 10 feet tall. All of the leaves and fruit, many of the twigs, and two-thirds of the Iceryæ were killed.

(112) Sublimed half a pound of sulphur and passed it over hot charcoal, as in the preceding experiment. Passed it into the tent in eight minutes, and left tent on the tree twenty-two minutes longer. Tree 10 feet tall. Five-sixths of the leaves, two-thirds of the fruit, a few of the twigs, and one-half of the Iceryæ were killed.

(113) Sublimed 6 ounces of sulphur and passed the vapor over hot charcoal, as in experiment 111. Passed it into the tent in one hour, and then removed the tent. Tree 10 feet tall. Eleven-twelfths of the leaves, all of the fruit, and many of the twigs were killed; found no living Iceryæ.

(114) Sublimed 2 ounces of sulphur and passed the vapor over hot charcoal and into the tent. The sulphur was put into a tight iron vessel, through the lid of which passed a small pipe leading to the pipe by which a Cummings' blower was attached to the horizontal furnace containing the charcoal; the sulphur was sublimed by the use of a small kerosene stove placed beneath the vessel containing the sulphur, and as the vapor from the sulphur rose it was blown over the hot charcoal into the tent. Passed the vapor into the tent in forty minutes and left the tent on the tree five minutes longer. Tree 10 feet tall. Seven-eighths of the leaves, all of the fruit, and many of the twigs were killed; found no living Iceryæ.

(115) Passed the vapor of 2 ounces of sulphur over hot charcoal and into the tent. The furnace was the same as that described in experiment 111, except that it was placed vertically and that its length had been increased to 3 feet; the vessel containing the sulphur was led into one side of the furnace, and to its lower end was attached a piece of gas-pipe leading into the furnace at a point about one-fourth of the height of the furnace. The sulphur placed in this vessel soon melted and ran down the gas-pipe and into the furnace, where it was vaporized and its vapor blown over the hot charcoal and into the tent through a pipe passing out of the upper end of the furnace and leading into the lower part of the tent. The gas-pipe below the vessel containing the sulphur was provided with a stop-cock, to regulate the flow of the melted sulphur. The sulphur was run into the furnace in twenty minutes, and the tent was left on the tree five minutes longer. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(116) Run 2 ounces of sulphur into furnace in ten minutes, and allowed the vapor to pass over the hot charcoal and into the tent of its own accord. After running the sulphur into the furnace for five minutes the air in the tent was stirred with a Cumming's blower, which drew the air out at the top of the tent and forced it in at the bottom. Left tent on tree half an hour. Tree 10 feet tall. Furnace same as used in preceding experiment. No leaves and only a few Iceryæ were killed.

(117) Run 2 ounces of sulphur into furnace in ten minutes, then stirred air in tent for five minutes, and left tent on tree half an hour longer. The sulphur vapor was allowed to pass over the hot charcoal and into the tent of its own accord. Furnace same as used in preceding experiment. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(118) Run 3 ounces of sulphur into furnace in fifteen minutes, then stirred air in tent for five minutes, and left tent on tree twenty minutes longer. Furnace as in preceding experiment; sulphur vapor passed into tent of its own accord. Tree 10 feet tall. Only a few of the leaves and about one-eighth of the Iceryæ were killed.

(119) Run 5 ounces of sulphur into furnace, and allowed the vapor to pass into the tent of its own accord. After the melted sulphur had run into the furnace for eight minutes its flow was stopped, the pipes leading into the tent were disconnected, and the blower was attached to the furnace, and the latter was fired up for

four minutes, after which the pipes were again connected, and the rest of the sulphur run into the furnace in six minutes; the air in the tent was then stirred for five minutes. Tent left on tree fifty minutes. Only a few of the leaves and Iceryæ were killed.

(120) Run 20 ounces of sulphur into the furnace in twenty-four minutes, and allowed the vapor to pass into the tent of its own accord. After the sulphur had been running into the furnace for eight minutes its flow was stopped, the pipes disconnected, and the furnace fired up for two minutes; and this was repeated until all of the sulphur had been run into the furnace, after which the air in the tent was stirred for five minutes. Left tent on tree for one hour. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(121) Run 5 ounces of sulphur into the tent in twenty-five minutes. The furnace was fired up after the sulphur had been running into it for five minutes, and this was repeated until all of the sulphur had passed into the furnace, after which the air in the tent was stirred for five minutes. Left tent on tree one hour. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(122) Run 16 ounces of sulphur into furnace in twenty-five minutes, then stirred air in tent for five minutes. The furnace consisted of a piece of terra-cotta pipe, 3 feet long and 8 inches in diameter; a hole was made through it near the bottom by which to light the charcoal in the furnace, and there were four other holes along one side of the furnace for the purpose of firing up the latter, which was accomplished by the use of a Cummings' blower. The entire furnace was inclosed in a sheet iron to which the blower was attached, and a pipe led from the top of the furnace into the bottom of the tent; the sulphur was inserted in a piece of gas-pipe that passed to the inside of the furnace. Left tent on tree one hour. Tree 10 feet tall. The bisulphide was allowed to pass into the tent of its own accord. No leaves and about one-sixth of the Iceryæ were killed.

(123) Inserted 1¾ pounds of sulphur into furnace in forty minutes, inserting much of it through the hole in the furnace by which the charcoal is lighted; stirred air in tent almost continuously during the time that the sulphur was being inserted into the furnace; the bisulphide was allowed to pass into the tent of its own accord. Left tent on tree one hour and a half; disconnected furnace from tent half an hour before removing the latter from the tree. Leaves slightly injured; only a few Iceryæ were killed.

(124) Inserted 1½ pounds carbonate of ammonium in lower part of furnace in thirty minutes, allowing the vapor to pass over the hot charcoal and into the tent of its own accord. After inserting the ammonium the air in the tent was stirred for ten minutes. Left tent on tree for one hour; disconnected furnace from tent fifteen minutes before removing latter from tree. Tree 10 feet tall. No leaves and only a few Iceryæ were killed. A whitish deposit remained upon the leaves.

(125) Inserted 2¾ pounds of sulphur in lower part of furnace in thirty-five minutes, during which time the air in the tent was stirred almost continuously. Left tent on tree one hour; disconnected furnace from tent five minutes before removing latter from the tree. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(126) Inserted in lower part of furnace 3 pounds of sulphur in packages of 8 ounces each at intervals of six minutes apart; during this time the air in the tent was stirred occasionally. Left tent on tree one hour; disconnected furnace from tent five minutes before removing the latter from the tree. Tree 10 feet tall. Leaves slightly injured; only a few Iceryæ were killed.

(127) Inserted 5 pounds of sulphur into lower part of furnace in 10-ounce packages at intervals of six minutes apart. After the lapse of thirty minutes from starting the air in the tent was stirred for ten minutes. Left tent on tree for one hour and a half; disconnected the furnace from the tent five minutes before removing the latter. Tree 10 feet tall. One-third of the leaves and three-fourths of the Iceryæ were killed.

(128) Put 3⅞ pounds of refuse tobacco stems on top of the red hot charcoal in the furnace and allowed the vapor to pass into the tent for fifteen minutes; then blew a blast of air through the furnace for five minutes, without disconnecting the furnace from the tent, after which the vapor was allowed to pass into the tent of its own accord, and the air in the tent was stirred for ten minutes. Left tent on tree one hour; disconnected the furnace from the tent five minutes before the latter was removed from the tree. Tree 10 feet tall. Leaves uninjured; found no living Iceryæ.

(129) Inserted 3¼ pounds of sulphur into lower part of furnace in packages of 10⅖ ounces each, a package being inserted at the end of every twelve minutes. After all of the sulphur had been inserted the air in the tent was stirred for ten minutes. Left tent on tree one hour and a half; disconnected furnace from tent five minutes

before removing the latter from the tree. Tree 10 feet tall. Leaves uninjured; only a few Iceryæ were killed.

(130) Put 1 pound of the best grade of fused potassium cyanide on top of the red-hot charcoal in the furnace and allowed the vapors to pass into the tent. After the lapse of ten minutes the air in the tent was stirred for ten minutes. Left tent on tree half an hour; disconnected furnace from tent five minutes before removing the latter from the tree. Tree 10 feet tall. Neither leaves nor the Iceryæ were injured.

INDEX TO EXPERIMENTS.

Following is an alphabetical list of the substances and combinations used in the preceding experiments; the numbers are those of the different experiments. I have prefixed an asterisk (*) to those which proved fatal to at least one-sixfh of the Iceryæ:

REPORT ON EXPERIMENTS AGAINST SCALE-INSECTS.

By ALBERT KOEBELE, *Special Agent.*

LETTER OF SUBMITTAL.

ALAMEDA, CAL., *December* 26, 1887.

SIR: I herewith submit report of continued experiments with kerosene emulsion and resin compound upon various scales, plant-lice, etc., made at Alameda during 1887, according to your instructions.

Very respectfully,

ALBERT KOEBELE.

Prof. C. V. RILEY,
U. S. Entomologist.

THE VALUE OF ARSENIC AS AN ADDITION TO THE KEROSENE EMULSION.

In the main I followed your suggestion while here in April last, in preparing the kerosene emulsion, viz, to emulsify with resin compound, and use arsenic acid in addition. I am glad that your hopes in this wash are verified. In every instance where your proposed arsenic acid was added either to emulsified kerosene or resin compound there has been a complete extermination of the scales.

At first too much of the arsenic acid was used, resulting in more or less injury to trees treated, particularly so in weak washes.

The best results in preparing the emulsion were obtained by taking 1 part of the kerosene to 1 part of lukewarm resin compound. Thus I obtained 2 gallons of emulsion in less than three minutes that did not show any trace of separation before the end of twenty-four hours. The result would have been not quite so good if the resin compound had been used hot in emulsifying, and still less so if 2 parts of kerosene had been used to 1 of resin compound; but still this last will make a very good emulsion if prepared properly, which is easily done. It has the good quality of spreading instantly over the leaves if sprayed with diluent, as well as do soap washes. None of the experiments made during dry weather with this emulsion alone, *i. e.*, without the additional arsenic acid, were appreciably effective. The evaporation was very rapid and in ten minutes after application no trace of the wash could be seen.

In addition I include results of various experiments with resin compound, especially upon Aphidæ, which it affects admirably; and, at the same time, a wash can be prepared which will destroy all Aphids and not injure the larvæ of Syrphus flies nor prevent the parasites from hatching from the infested Aphids.

Experiment 158.*—Pure kerosene.

Pure kerosene on *Aspidiotus rapax* on Pear. Applied with rag February 22, on small and sickly tree, with only one living branch. February 27 a heavy shower washed off a number of scales which were loosening. May 5, all the dormant buds starting out, trees growing vigorously; not a living scale could be found.

Experiment 165.—Kerosene emulsion.

Prepared of half lukewarm resin compound† and half kerosene; worked for two minutes with pump. This formed a good emulsion. In twenty-four hours oil began to appear on top, and on the fifth day three-eighths of an inch of oil had collected on top, in bottle with 4 inches of emulsion reserved.

Emulsion, 1 part; water, 10 parts. Applied July 27, on *Aspidiotus rapax* on Pear. Cloudy day and a little rain the following night. Examined August 1 and 19; no appreciable result; only small part of young scales were destroyed; new scales forming numerously.

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*The numbering of these experiments is consecutive with the series published in the annual report for 1886, pp. 560 to 572.

† Dissolve 3 pounds of sal soda and 4 pounds of resin in 3 pints of water above fire; when properly dissolved add water slowly, while boiling, to make 36 pints of compound.

Experiment 166.—Kerosene emulsion 165.

One part emulsion to 20 parts of water. Applied July 27. Destroyed but few of the young scales; tree full of newly-formed scales August 19.

Experiment 167.—Kerosene emulsion.

Made of kerosene, 2 parts; resin compound, 1 part. Prepared cold by working with pump for 2 minutes. This will make a good emulsion, but separates sooner than 165.

One part of the emulsion to 8 parts of water were applied August 4 on lemon tree full of *Lecanium hesperidum.* About three-fourths of the scales were destroyed, and they were soon on the increase again.

Experiment 169.—Kerosene emulsion 167.

One part of the emulsion to 5 parts of water. Applied August 27, on *Aspidiotus sp.*, on Currant, *A. rapax* and *Mytilaspis pomorum* on Apple, which was also badly infested with Wooly Aphis (*Schizoneura lanigera*) and Red Spider. This destroyed only about half of the scales on Currant (which are exceedingly hard to kill), and where well protected the effects were not visible. Result on *A. rapax* on Apple much better, but not all died. Of *M. pomorum* only young scales were destroyed. Wooly Aphis and Red Spider were killed, but the eggs of the latter were not affected. Not the slightest injury to plants visible.

Experiment 170.—Kerosene emulsion 167.

One part of the emulsion to 10 parts of water. Applied August 27, on *Aspidiotus sp.*, on Currant, *A rapax* on Apple and Cherry.

September 1, about one-third of the scales dead on Currant; found many dead young and eggs under mother scales; plant full of newly-hatched young. Of *A. rapax*, on Apple and Cherry, all scales dead except an occasional one under mother scale; a few gravid females living. October 7, only a small number of scales living on Apple and Cherry, but numerous on Currant. Plant not at all injured.

Experiment 171.—Kerosene emulsion 167.

Emulsion, 1 part; water, 15 parts. Applied August 27, on *Aspidiotus sp.*, on Currant and *A. rapax* on Cherry. This scarcely affected the scales.

Experiment 172.—Kerosene emulsion 165.

Emulsion, 1 part; water, 4 parts. Applied August 27, on *Aspidiotus sp.*, on Currant and *A. rapax* on Plum in bearing. September 1, about four-fifths of the scales on Currant dead, and none living could be found on Plum. Plants show no trace of wash. October 7, scales on Currant increasing; found one living on upper branch of Plum. November 28, scales very numerous on Currant again.

Experiment 173.—Kerosene emulsion 165.

Emulsion, 1 part; water, 8 parts. Applied August 27, on *Aspidiotus sp.*, on Currant, and *A. rapax* on Peach. September 1, scales and eggs, where not well protected, all dead on Currant; on Peach about four-fifths destroyed. This tree was covered with red spiders, nearly all of which were destroyed by this wash. October 7, scales increasing on both plants. November 28, scales numerous again, but more so on Currant.

Experiment 174.—Kerosene emulsion 165.

Emulsion, 1 part; water, 12 parts. Applied August 27, on *Aspidiotus sp.*, on Currant. The result was nearly as good as in 173.

Experiment 188.—Kerosene emulsion 167.

This emulsion was prepared with hot resin compound and could not be united properly; part of free oil floating on top. One-half emulsion to one-half water. Applied September 13, on a strong young apple tree in bearing; also on Cherry. September 21, all the fruit on Apple spotted; leaves on sunny side partly burned; eggs of *M. pomorum* not affected, nor eggs of red spider; tips of leaves on Cherry black on south side; otherwise no injury to this tree. October 7, apple tree in good condition; some of the leaves on south side partly dry; wash on Cherry not visible; no injury was done here. November 22, apple tree had made few new growths on one branch and had bloomed on this part; eggs of *M. pomorum* not yet hatched; all in good condition.

Experiment 177.—Kerosene emulsion 167 with arsenic, of which 1 pound in 55 gallons wash.

One-half pound of arsenic and one-half pound sal soda boiled in one-half gallon water until dissolved, and this diluted in 20 pints of water.

Experiment 178.—Kerosene emulsion 167 with arsenic, of which 1 pound in 55 gallons wash.

Emulsion, 1 part; water, 15 parts. Applied August 30, on *A. rapax* on Pear. September 1, leaves spotted, turning brown. September 7, all leaves dead and dry; bark not injured except on few smallest twigs; scales all killed. October 7, tree bringing forth new shoots all over; some in blossom; all buds not dead growing. November 22, new shoots of 8 inches in length had formed; fruit did not set; tree in good condition; still growing. December 17, tree fresh and green; no scales whatever.

Experiment 179.—Kerosene emulsion 167 with arsenic, of which 1 pound to 52½ gallons wash.

Emulsion, 1 part; water, 20 parts. Applied August 30, on *Aspidiotus sp.*, on Currant, and *A. rapax* on Cherry. September 7, leaves nearly dry and falling off; scales appear to be dead, but still have their natural color. October 7, all scales and eggs dead; young shoots forming on Currant. November 22, currant plant still growing; some blossoms and young fruit; no scales. December 17, no scales; a few of the berries have become mature, but are small.

Experiment 180.—Kerosene emulsion with arsenic, of which 1 pound to 55 gallons wash.

Emulsion, 1 part; water, 2 parts. Applied August 30, on *Aspidiotus sp.*, on Currant, *A. rapax* and *M. pomorum* on Apple. September 7, scales on Currant, where in thick layers, not all dead; a few eggs and newly-hatched young found; *A. rapax* on Apple not all dead; gravid females and eggs of *M. pomorum* not affected; leaves of Apple dry and those on Currant nearly so. October 7, scales on Currant all dry; plant growing; *A. rapax* on Apple all dead; eggs of *M. pomorum* in good condition. November 22, no living scales on Currant, this still growing; eggs of *M. pomorum* still intact.

Experiment 181.—Kerosene emulsion 165 with arsenic, of which 1 pound in 55 gallons wash.

Emulsion, 1 part; water, 15 parts. Applied August 30, on *Aspidiotus* on Currant. September 7, leaves of plant all dry; a few of the scales still living; also eggs and newly-hatched young found. October 7, all scales dead; plant in good condition. November 22, no living scales can be found. December 17, no living scales on plant.

EXPERIMENTS WITH RESIN COMPOUND AND ARSENIC.

Experiment 185.—Resin compound and arsenic, of which 1 pound in 85 gallons wash.

Compound, 1 part; water, 16 parts. Applied September 2, on *Lecanium hesperidum* on Orange.* September 7, most of the young and tender shoots destroyed; a few leaves falling; scales appear to be dead. September 13, scales all dead; leaves still falling, only few remaining on tree. November 22, no living scales; tree growing; fall of young shoots, but very few of the old leaves remaining. December 17, found four young scales, which evidently have come from neighboring trees; tree in good condition again; still growing.

Experiment 186.—Resin compound and arsenic, of which 1 pound in 90 gallons wash.

Compound, 1 part; water, 8 parts. Applied September 2, on *L. hesperidum* on Orange. September 7, scales dead; found a few living young under mother scale; a few leaves falling. September 13, all scales dead; about half of the leaves have fallen. October 7, no living scales. November 22, about one-third of the leaves remaining; tree otherwise in good condition. December 17, tree in good condition; no living scales.

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* All orange trees experimented on were in poor condition, received no water during summer, and leaves were curled.

Experiment 187.—Resin compound and arsenic, of which 1 pound in 100 gallons wash.

Compound, 1 part; water, 4 parts. Applied September 2, on *L. hesperidum* on Orange. September 7, scales all dead. September 13, no living scales; about one-fourth of the leaves have fallen. October 7, tree in good condition; not injured beyond the loss of a few leaves; all scales, lichens, and fungus destroyed. November 22, tree in very good condition; no living scales.

Experiment 189.—Resin compound and arsenic, of which 1 pound in 170 gallons wash.

Compound, 1 part; water, 16 parts. Applied September 13, on *L. hesperidum* on Orange. October 7, many scales still living; nearly half of the leaves have fallen. November 22, all scales dead; tree in good condition. December 17, no living scales on tree.

Experiment 190.—Resin compound and arsenic, of which 1 pound in 300 gallons wash.

Compound, 1 part; water, 4 parts. Applied September 13, on *L. hesperidum* on Orange. September 21, scales nearly all dry; no leaves whatever have fallen. October 7, scales all dried up; no leaves have fallen. November 22, no scales on tree, which is in very good condition.

EXPERIMENTS WITH RESIN COMPOUND.

The strongest application of this was made on Pear and Plum, infested with *A. rapax*, August 27; three parts of the compound to four of water (Experiment 176). September 7, all traces of wash had disappeared, not injuring the foliage of Plum. The leaves of Pear were very brittle for the first few days, and some tips of older leaves turned black, but none came off, and otherwise no injury was done. An occasional living scale was found October 7.

One part of the compound to two of water. Applied February 28, on *A. rapax* on Pear (Experiment 160). Rain fell for two days following, and the result, perhaps, was not as good as it would otherwise have been. A careful examination on March 8 showed that a large part of the eggs had been destroyed, also all the young and many of the older scales. On this tree they did not increase, and November 21 hardly any living scales could be found. Other experiments were made of the same strength, on *Aspidiotus sp.*, on Currant and *A. rapax* on Pear, August 27 (Experiment 175). All but a few gravid females were destroyed on Pear, and very few remained on such places where they had been in thick layers on Currant. October 7 a few young scales were found on both plants; but hardly any were living November 22. The wash disappeared in ten days, leaving the trees in good condition; no leaves fell.

Three parts of compound to eight of water was applied on Orange, thickly infested with *Lecanium hesperidum*, September 2 (Experiment 184). In five days after application no living scales could be found, and none on November 22. The tree was not at all affected by the wash.

One part of compound to four of water applied on Pear, with *A. rapax*, February 28 (Experiment 159), destroyed all the smaller and part of the older scales, but none after the scales were increasing again. The same strength was also applied on *Diaspis rosæ* on Rose, March 8 (Experiment 162). This effectively cleared the plant of scales. And again, on *L. hesperidum* on Orange, September 2 (Experiment 183). All scales were dead September 7, and none living could be found November 22.

One part of compound to eight of water, on *L. hesperidum* on Orange, September 2 (Experiment 182), destroyed nearly all scales, but many living young were found under mother scales September 7; only very few living scales were found on trees September 13 and October 7; but on November 22 the tree was covered with scales again.

Other experiments of this strength were made and may be worthy of mention. On *L. oleæ* on Orange and on several peach trees in full blossom, infested with the *Lecanium*, bred from Oak (*Q. agrifolia*); here also many of the scales survived; the trees subsequently were loaded with fruit, as well as those not treated.

EXPERIMENTS ON APHIDIDÆ WITH RESIN COMPOUND.

The Wooly Aphis (*Schizoneura lanigera*), the Cabbage Aphis (*Aphis brassicæ*), the Plum Aphis (*Aphis pruni*), and Aphis on Rose (*Siphonophora rosæ*). Two experiments were made at Berkeley on the Wooly Aphis, in conjunction with Messrs. Klee and McLennan. One and three parts of the compound were used to eight of water.

Owing to imperfect spraying only the last did effective work. The leaves of the trees were falling at the time of spraying, and the effect of the solution, especially on tree where three to eight parts of wash were applied, was very noticeable, as the first tree lost about half, while the second lost nearly all its leaves. On my visit to the place a month later, however, there was little difference in the trees treated and others infested with Wooly Aphis, for these also began to lose their leaves about two weeks after, as I was informed by Mr. McLennan, the gardener, who is a very careful observer. Mr. Klee recommends this wash in the proportion of 1½ pints compound to one gallon water.*

I have made numerous other experiments and always had complete success in killing this insect with one part compound to eight parts of water. With this proportion also those on root which were reached were killed. I would recommend the same, *i. e.*, one part of the compound to six parts of water, on Wooly Aphis. On the other hand, the Plum Aphis, Cabbage Aphis, etc., are much easier to kill; only one part of compound to eight of water was used in experiment at Berkeley (August 10) on Plum Aphis, and none were living on examination August 17. At this strength the Aphis will die instantly and will not even be able to move a leg if once wet. I have killed them successfully even with a wash as low as one part of the compound to sixteen parts of water; and would recommend one part of the compound to twelve parts of water, for Plum Aphis, Aphis on Rose, etc. At this strength it may be safely used on any garden and even on the most tender hot-house plants, without the slightest injury to plants themselves. It should be used somewhat stronger on the Cabbage Aphis. One part of the compound to eight parts of water will be found effectual. At this strength it was found that the larvæ of Syrphus flies were not injured by wash, nor were the parasites which infested the Aphis in any way affected, providing the skin of the Aphis was dry when sprayed.

A lot of House Flies (*Musca domestica*) which had concentrated out of doors were sprayed with this solution and died almost instantly. A large Flesh Fly (*Sarcophaga*) thrown into a weak solution (1 to 16), taken out and set on board, never moved its legs again. Fifteen minutes later, slight convulsive movements were noticed on under side of body, and soon after all life was extinct. A Codling Moth (*Carpocapsa pomonella*), sprayed with a solution of 1 to 8, was dead in nine minutes. Cut Worms (larvæ of *Agrotis saucia*), dipped in this mixture were not affected.

It will be of interest to note that while in Los Angeles in April, 1887, the following labels on trees treated for Red Scale (*A. aurantii*) were still present: "Experiments with resin soap 127, 147, and 149."† All these trees were free from Red Scale and *L. oleæ*, but full of Icerya. "Experiments with resin compound 133 and 156." No Red Scales could be found on these trees, but *L. oleæ* was numerous on tree of experiment 133. Both trees were badly infested with Icerya.

REPORT ON THE SEASON'S OBSERVATIONS, AND ESPECIALLY UPON CORN INSECTS.

By F. M. WEBSTER, *Special Agent.*

LA FAYETTE, IND., *November* 1, 1887.

SIR: I herewith transmit my annual report for the year 1887 of work and observations made under your direction.

Stationed in the Southern States during spring and much of the summer, working under your direction, and upon an entirely different class of insects from those affecting field crops, has prevented me from accomplishing much in the way of investigating the habits of such species as affect our cereal grains. For this reason, I have brought together the results of a considerable number of observations in various parts of the West and Southwest relating to insects affecting Indian corn.

Under head of "*Memoranda*" I have included a number of facts obtained, which, though not properly coming under the head of corn insects, are considered of sufficient value to warrant publication.

Books and collections of insects having been inaccessible to me much of the time, I have in such cases relied upon yourself and assistants for determination of species, without regard to my own ability to determine them myself.

Respectfully,

F. M. WEBSTER.

DR. C. V. RILEY,
U. S. Entomologist.

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* Pacific Rural Press, December 17, 1887, p. 488.
† See Rep. Entom. Dept. Agr., 1886, pp. 571, 572.

THE TWELVE-SPOTTED DIABROTICA.

(*Diabrotica 12-punctata.*)

While in the South during the spring of 1886 we frequently heard of fields of young corn being seriously injured, during some seasons, by a small white worm which attacked the roots, usually during April. From the description given us of the pest and its manner of attacking the plants, we first thought it might be the larva of *D. longicornis*, as the habitat of that species is known to extend southward to Central America.

On April 12 of the present year we were enabled to solve the problem by finding considerable numbers of these larvæ in a field of corn in Tensas Parish, La., where they were working considerable mischief by killing the young plants. As observed by us, their mode of attack differed from that of their northern congener in that they did not appear to attack the fibrous roots or bury themselves in longitudinal channels excavated in the larger roots. On the contrary, they burrowed directly into the plants at or near the upper whorl of roots, which almost invariably resulted in the death of the plant. These larvæ were much more active than those of *longicornis*, and on being disturbed would make their way out of their burrows and attempt to escape by crawling slowly into crevices in the soil, or if it were finely pulverized they would work their way down into it out of sight. Often several individuals, varying greatly in size, would be found about a single plant. On the 20th of same month, in another field, we found the larvæ much more numerous and the crop injured fully 75 per cent. Plants here, 6 to 8 inches high, were withering up and discoloring. Both of these fields had produced cotton the preceding year.

The adult beetles were frequently seen before we observed the larvæ, but they were not abundant about the plants in the corn-fields, being usually on the yellow blossoms of a species of Aster which springs up in cultivated grounds early in the spring in great abundance. No pupæ were found, although careful search was made for them. We have elsewhere shown that the adult insect attacks leaves of young corn in Indiana.*

THE CORN PLANT-LOUSE.

(*Rhopalosiphum maidis.*)

So far as we are aware, this species is not recorded as injuring corn in any of the Gulf States. Considerable damage, however, is done by the root form in both Louisiana and Mississippi, and we observed the aërial form also in great abundance during June and July of the present year in both of these States.

In October, 1885, we transferred some volunteer plants of corn from the field of fall wheat, where they grew, to some breeding-cages. The plants were thickly populated with winged females, and these were carefully secured with the plants, both being subjected to the same conditions which would have influenced them had they remained in the field, except that the ants in attendance were excluded. On May 8, 1886, corn was planted in these cages and grew therein till after the 15th of June without a single individual of either root or aërial form being on or about the plants, and they were then thrown out.

In the meantime corn had been planted indoors in pots, and on June 24 these were placed in a field where serious injury was being done by the root form of the Corn Aphis. The pots were buried in the earth between the rows until the soil within was on a level with, and not obstructed in the least by, the tops of the pots, from the surface of the ground. Several hills seriously infested were pulled up in the vicinity of these pots, thereby exposing both roots and plant-lice to the sun.

The next day the ants were burrowing about the plants in the pots, and a few days later the roots were well stocked with lice, many of them being full-grown. Besides this we had observed ants with lice in their mouths over a yard distant from the hills which had been pulled up, thereby indicating that the bereft were supplied with homes on the neighboring hills as well as on the potted plants.

Grasses and other plants were examined during the autumn, but no distinguishable corn-plant lice were obtainable.

The present season we were absent from home from the middle of March until after the 20th of May. On the 27th of this month, however, we found winged, viviparous females on the roots of corn in a field planted on the 18th instant. A thorough search revealed the fact that the wingless lice were all very small. A heavy rain had fallen on the 23d, and it was only where fresh mounds thrown up

*Indiana Agricultural Report, 1885, p. 198.

by ants were observed that the roots were found tenanted, thus indicating, as did the size of the young lice, that these winged females had appeared on the roots within the preceding four days. The most careful search failed to reveal the origin of these winged lice, as no ants were observed transporting them about, although the latter were very busily engaged in running up and down over the young corn. If, however, a louse were placed on the corn, it was soon found and at once transported to a gallery about a hill of corn. The winged females were not always on the roots of the corn, by any means, but often on the stem, and in one instance a female was observed on a root of grass (*Setaria glauca*) giving birth to her young. Even in this case she was in a gallery surrounded by ants, who doubtless removed her progeny to other quarters.

These observations led me to conclude that the Corn Plant-louse does not live over winter in the fields, nor are the eggs deposited about the corn in the fall, but that they are deposited about the roots of some other plant, most likely one of the grasses. These eggs develop a wingless brood, probably, from which the winged females which first appear in the corn-fields originate. These in turn throw off a wingless brood, and these again a winged brood, thus alternating from one to the other. Also that ants, of which three species attend these plant-lice, viz, *Lasius flavus*, *Formica schaufussii*, and *F. fusca*, are not in the least responsible for their distribution over the fields, although the protection which they afford them greatly increases their numbers and the amount of injury done in the corn-fields.

During June, 1886, a number of experiments were made to test the immediate effect of fertilizers, including salt, upon the lice, and also to learn if the ants could be induced thereby to abandon or remove their favorites to other plants.

The substances used were two commercial fertilizers, Bunner bone dust and bone guano, barn-yard manure, and common salt. A double experiment was made with each. The first two substances were applied (1) by scattering a table-spoonful on the surface of the ground about the plant and sprinkling with water sufficient to at once wash it into the soil, and (2) by drawing the earth away from the roots, scattering the same amount of fertilizer about the roots, then replacing the earth and sprinkling the surface less thoroughly than with the first. The barn-yard manure was well-rotted and a quantity sufficient to fill a pint measure was used in the same way. The salt was used like the manufactured fertilizers.

The result, a week after, was that the lice were still about the roots in every case, and except where salt was used, they were found in the midst of the substances applied. The salt only drove them from one portion of the roots to another. Sand dampened with kerosene was applied in the same way, the surface application having no effect, while that placed about the roots had the same effect as the salt.

That proper fertilizers applied to the soil are a general preventive was clearly proven by the appearance of the crop on a series of eighteen plots, on the University farm. These plots were located side by side and numbered 1 to 18. All had produced corn for the six previous crops, those plots of even numbers not having been fertilized during that time. Plots 1, 7, 13 had, three and again two years previous, received applications of gas-lime; plots 3, 9, 15 had received applications of superphosphates during the same years, while plots 5, 11, 17 had received similar treatment with barn-yard manure. The result, up to July, 1886, was that the corn on all plots except those fertilized by barn-yard manure was small and uneven in growth, while on plots 5, 11, 17 the plants were fully a third larger, more thrifty, and far less uneven in height. In fact, these plots could be distinguished from any of the others at a distance from the field. It was unfortunate that the experiments being carried on forbade any examinations of the roots, in order to estimate the relative number of plant-lice inhabiting each series of plots.

CORN BILL-BUGS.

(*Sphenophorus sculptilis.*)

On June 9 of present year, J. B. Lutz, of Wea, Tippecanoe County, Ind., informed us that ants were destroying his corn; that he had planted one of his fields three times, and each time the corn had been destroyed after it came up. Feeling certain our friend was laboring under a mistake, we visited his field on the 13th instant and found the depredator to be an old offender, but with few exceptions it had not been observed injuring corn in the Western States. Hence it was to us a rather unexpected appearance here in Indiana.

We found quite a number of the beetles engaged in puncturing the plants just below the surface of the ground. The result of this puncture was not, in all cases, the destroying of the plant, although practically the outcome, so far as the crop was concerned, was the same, for instead of a single stalk many laterals or suckers were

put forth from the same roots, and often one sheath covering all at base. The base of this mass of suckers had the appearance of having been wounded and scarified, while the leaves were riddled with holes arranged transversely across the leaf from the puncture of the insect before the leaf had become unrolled. Besides, the leaves were ragged and gnarled, and often aborted.

We had observed the same feature in a corn-field in Tensas Parish, La., in April, but in that instance had supposed that the abnormal growth was due to the work of the larvæ of *Diabrotica*. This, indeed, might have been the case, as both puncture the stem at nearly the same place. Since observing the same feature in Mr. Lutz's field, we are inclined to suspect that some species of *Sphenophorus* might have been at work in the Louisiana field before we saw it, although we found none of the adults there. Still, *D. 12-punctata* is very common in the Northern States, and it will not be surprising if we hear of its work before long.

We found no larvæ or pupæ in Mr. Lutz's field, and as we soon afterwards returned to the South, had no opportunity of again examining it. Either through the effect of the beetles or dry weather, or both, the crop proved a failure. Only the low portion of the field, which comprised about 20 acres, was affected by *Sphenophorus*, the higher parts being uninjured.

MYOCHROUS DENTICOLLIS.

The adult beetles were observed in considerable numbers in fields of young corn in Louisiana during April of the present year. They were found in the soil about the stems of the plants, at or near the surface of the ground, and attack the young corn by gnawing the outside of the stems, but not, so far as we observed, cutting them off or climbing over the leaves. No serious injury was noticed, but the species is a common one, both North and South, although we had never observed it in corn-fields before.

FLEA-BEETLES.

(*Chætocnema confinis* and *Psylliodes interstitialis*.)

The first of these species was observed in Tensas Parish, La., early in April of the present year, where the adults were engaged in eating out the parenchyma from the young corn leaves, appearing to injure the plants considerably, although not permanently. During August these beetles affected young wheat at La Fayette, Ind., in a similar manner.

On June 21 both of these species were observed on corn in Pike County, Ind., in great numbers, the *Psylliodes* predominating. Here the *Chætocnema* followed the same method of attack on the leaves of the plants, but did not appear to select either the smaller or younger plants nor the more tender foliage, but was, if anything, more abundant on the lower than the upper leaves.

The *Psylliodes* worked in precisely the same manner, and on the lower leaves almost exclusively. These did not eat holes in the leaves at all, but seemed to gnaw out the parenchyma from beneath, leaving the upper epidermis and the longitudinal veins intact. Had the beetles desired more tender food, it could have been found in a small plot of much later corn only a few yards distant. This, however, was less affected than the larger. Elsewhere in the fields, we found them working on the leaves of Panic grass (*Panicum crusgalli*) in exactly the same manner.

THE GREASY CUT-WORM.

(*Agrotis ypsilon*.)

This was several times observed attacking corn in Louisiana; in one instance a stalk fully 10 inches high had been eaten into near the surface of the ground and destroyed.

Planters living in the low districts say that this or a similar species is very much more destructive just after an inundation.

ANTS.

(*Prenolepis nitens*.)

Various species of ants may be observed during autumn about the ears of unripe corn, especially if the kernels near the tip of the ears have been partly eaten by other insects or by birds. At La Fayette, Ind., during September, 1886, we several

times observed this species infesting the ears of corn, under circumstances which left no doubt as to their vegetal habits. The silk of the ears of corn where they were busily engaged was undisturbed, but down among its meshes were numbers of freshly-eaten kernels, and nothing but these ants in or about the ear, while the ants were very abundant.

Another species, *Formica schaufussii*, has been observed by us to eat kernels of seed wheat which had not been sufficiently covered after being sown in the field.

DRASTERIUS DORSALIS (?).

Larvæ which are supposed to be those of this species, as it is the only one of the genus common in Indiana and Illinois, have twice been surprised by me about La Fayette, under circumstances which lead to the suspicion that they attack corn. Although, as stated in report of last year, we have observed them in the vicinity of La Fayette attacking other larvæ, and other members of the genus are known to be carnivorous in the larval stage,* yet we have found them with their heads inserted in the stems of young corn, with no object about which could have induced them to do so if in search of animal food These larvæ were very abundant in Mr. Lutz's field, previously mentioned as attacked by *Sphenophorus*.

CHINCH BUGS.

(*Blissus leucopterus.*)

These were observed in considerable numbers during March, 1887, in Tensas Parish, La., about young corn, pairing and ovipositing as in more northern localities later in spring. We are informed that considerable damage was sometimes done by the young bugs to the young plants. This rather contradicts the theory often expressed by northern farmers, viz, that certain crops, including Spring Wheat, are the cause of their abundance. In the locality where we observed them the only small grain sown is an occasional patch of Fall Oats, grown for fodder, and an occasional but equally small field of Millet.

CORTICARIA PUMILA.

Found in abundance on the tips of ears of young corn, feeding upon the kernels during August and September, in the vicinity of La Fayette, Ind.

CALATHUS GREGARIUS (SAY) † VERSUS THE COLORADO POTATO-BEETLE.

On June 7 of present year Mr. Charles E. Lutz, of Wea, Tippecanoe County, Ind., sent us examples of the adult *Calathus*, asking what they were, and stating that they were engaged in the destruction of the eggs of *Doryphora* 10-*lineata*. In proof of this he had placed quite a number of these eggs in the box with his specimens. On opening the box, however, a few hours later we were unable to find a single egg, although there was ample proof that there had been many on the leaves inclosed. Mr. Lutz further stated that where these *Calathus* were abundant there were no larvæ of the *Doryphora*, while where there was a lack of the former the eggs and larvæ of the latter were very abundant. He had placed eggs where the *Calathus* could find them, and observed them devour these and also attack the young larvæ.

June 13, I visited the location and found exactly the same state of affairs as above indicated. In a small field, near the barn and out-buildings where the domestic fowls had had full range, the *Doryphora* was very abundant in all stages. There were here but few *Calathus*, they doubtless having been destroyed by the fowls. But a mile away, in a field of 4 acres, the case was entirely different. Here there were no eggs or larvæ to be found, although the adult *Doryphora* was common enough. In fact, far more damage had been done by the adult *Systena blanda*, Melsh., and to a less degree by *S. frontalis*, Fab. Great numbers of the *Calathus* were hiding in the vicinity under clods about the plants, and I was informed that they were observed roving about over these plants during the cool of the day. There was hardly a trace of the destructive propensities of the arch enemy of the potato throughout the whole field, although it had not been treated with any insecticide for several weeks.

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*Am. Ent., vol. 3, 1880, p. 247.

† A short notice of this insect and its habits was published in the Indiana Farmer of July 30, 1887.—F. M. W.

Under date of August 12, Mr. Lutz again wrote me as follows:

"In regard to the *Calathus gregarius* my observations have shown me that he is a great lover of the eggs of the Colorado Beetle.

"I noticed that when one was seen wandering around over the potato plants, if a bunch of eggs were to be placed in his way he would stop and devour them, and was not easily driven away.

"Again, I selected an equal number of hills, one-half of which had no beetles under them, while the other half had. I placed eggs on the hills, and in the morning the eggs were all eaten where there were beetles, while the others were undisturbed. The next evening I placed beetles under the other hills, and in the morning the eggs were gone.

"I had no slugs on my potatoes until the last week in June, when the *Calathus* began to disappear. In a few days after they disappeared the slugs came so fast that it became necessary to apply Paris green."

This species of *Calathus* we have found very common in Illinois and Indiana, and less common in Mississippi, Arkansas, and Louisiana. Dr. Le Conte (Proc. Ac. Phila., 1854, p. 36) gives its habitat as "N. Y. to Fla., Texas."

A NEW ENEMY TO THE BEAN AND COW-PEA.

While in Louisiana, in April of the present year, I observed adult beetles of the species *Cerotoma caminea*, Fab., infesting bean-plants in gardens, where they destroyed the plants by first eating holes in the leaves and later eating out the whole leaf between the larger veins. They were also observed to attack the Cow-pea in great numbers, in the fields, after the same manner.

On June 22, while visiting Hon. Samuel Hargrove, at Princeton, Gibson County, Ind., we again caught the same species in the act of destroying beans in the same manner as I had observed them earlier in the season in the South.

The species is common but not abundant in the West, from Minnesota southward; being more abundant in Louisiana than in Indiana or Illinois. Some specimens from Minnesota and New York are almost wholly of a clay-yellow color. To the Cow-pea this may prove a formidable enemy, especially in the South, and the beetles may easily be confounded with *Diabrotica 12-punctata* by the unobserving.

THE STRAWBERRY SAW-FLY.

(*Emphytus maculatus*, Nort.)

Dr. Riley has elsewhere stated* that this insect was double-brooded, the adults from the first brood of larvæ appearing in late June and early July. These adults at once ovipositing, give origin to a second brood of larvæ, which enter the ground in August and remain in their cocoons until the following April, when they pupate, and from these the progenitors of the first brood of larvæ emerge.

From the fact that the first brood of larvæ mature simultaneously with the ripening of the fruit, thereby precluding the possibility of destroying them by arsenical solutions, much interest has been centered in this second brood of larvæ, which, appearing after the fruit was gathered, would give the fruit-grower an opportunity of adopting those measures of destroying them which were previously inapplicable.

During the twenty years which have elapsed since the life history of the species was first made known no one has noticed a second brood, although some careful observers have attempted to do so.

Prof. William Saunders states that on July 8, 1873, larvæ, some of them half-grown and others full-grown, were brought to him from a garden near London, Ontario. A number of these larvæ were placed in flower-pots containing earth and leaves, such as were full-grown disappearing in the earth at once. On July 23 an examination showed these larvæ in their cocoons unchanged, except by being contracted in length.†

Later Prof. S. A. Forbes states that larvæ fully matured were placed in a breeding cage at Normal, Ill., on June 21, 1884, and soon entered the earth therein. On July 19 these larvæ were contracted in length, but had not pupated. On September 1, and again on November 24, they were examined and found practically unchanged, and the adults finally emerged May 14, 1885.‡ These last studies seemed to settle the matter of broods, so far as it was possible to do so with artificial environments.

On October 5, 1887, in the fields of Mr. J. C. Stevens, near Richmond, Wayne County, Ind., we were not a little surprised to find larvæ of this species, varying

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*Prairie Farmer, May 25, 1867; Ninth Report Ins. Mo., p. 27, 1877.

† Fourth Report Ent. Soc. Ontario, 1873, p. 18.

‡ Fourth Report State Ent. Ill., 1884, p. 77.

from two-thirds grown to nearly full-grown, feeding upon strawberry plants, not single, but by hundreds. So abundant were they, in fact, that by remaining stationary we could count them by dozens on the leaves about us, and we advised Mr. Stevens to sprinkle the infested fields with Paris green and water as a protection against them next year.

The question as to what brood these larvæ belonged is a perplexing one. Assuredly they were not of the first, and the main point to decide is, were they the delayed second brood or were they a third brood. We confess being unable to decide the matter.

Below is given a tabular statement of the conditions most likely to influence the species during the time intervening between February 28 and September 30, although it seems hardly probable that meteorological influences could have caused any material change in the time of appearance of the first brood of larvæ:

Mean monthly temperature, variation of the same, and monthly rain-fall at Richmond, Ind. Lat. 39.51 *N.; elevation,* 969 *feet above the sea.*

1887.

	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
Mean temperature..................degrees..	37.3	50.2	68.5	72.7	83.3	71.1	64.7
Variation..............................do..	67 15.52	84 25.59	84 52.32	94 58.36	101 66.35	96 50.46	92 30.62
Rain-fall..............................inches..	2.48	4.16	3.76	2.32	2.18	3.45	0.84

THE WHEAT WIRE-WORM.

(*Agriotes mancus*, Say.)

It quite frequently occurs that fields of Fall Wheat suffer severely in Indiana by reason of the attack of Wire-worms, and, so far as specimens have been referred to us, the species has been determined as the one under consideration. The general verdict of farmers is, that these ravages are in fields which have the preceding year been broken up from the sward, and therefore it is the second crop which is injured.

The present season appears to have favored the development of these worms, and serious injury to young wheat by larvæ unquestionably belonging to this species has been reported from several parts of this State. A study of the fields infested reveals some interesting features, especially when considered in connection with remedial or preventive measures.

On the 17th of October of the present year opportunity was offered us to examine an infested field in the southwest part of La Grange County. The field consisted of 20 acres, and had been cleared of timber, excepting the larger stumps, and broken up several years previous, so that the present was the fifth or sixth successive crop. The present season no crop was raised, and in June the greater portion of the stumps were blown out with dynamite and the débris piled about the remainder and burned. The now entirely cleared field was plowed in June and harrowed twice before harvest (the latter part of June or first of July). After this it was cultivated once and harrowed once. Then, about the 15th of September, it was harrowed twice and sown to wheat. The preceding crops had consisted of both corn and wheat, and the only vegetation growing on the ground this season was a species of Amaranth, the turf about the stumps being nearly all destroyed in June. The present crop was, at the date of examination, damaged fully 35 per cent.

Mr. J. N. Latta, a very careful observer, residing in the vicinity of the field just mentioned, writes us, under date of November 17, that there are two other fields in the same neighborhood which are still more seriously injuredby Wire-worms. One of these fields was broken in the fall of 1886, and a crop of wheat sown thereon, the present being the second crop, both of wheat. The other field was one-half in clover and the other half in timothy. The first crop was of corn, the second of wheat like the present. The destruction in the latter field is greatest on ground formerly devoted to clover and least on that portion which was set with timothy.

Under date of October 23 Mr. F. P. Applegate, of Greensburgh, Decatur County, complained of serious damage to one of his fields of wheat by this pest, the injury being greatest on clay lands. Writing again under date of November 7, Mr. Applegate states that his field, injured by Wire-worms, was broken last March, and later planted with corn, having then been devoted to clover but one year. The pres-

ent crop of wheat was sown between the 15th and 20th of September. By October 23 fully one-fourth of the growing plants had been destroyed by the wire-worms, and a great deal of damage had been done by the pest elsewhere in his locality.

Mr. G. A. Applegate, of Mount Carmel, Ind., in a recent communication gives a rather abnormal instance, from which he states that the worst infested field in his vicinity was in Hungarian grass this year, the stubble turned over and the wheat sowed. This land was in corn two years, rye sowed among the corn the second year, and this followed by Hungarian grass, as stated.

Personally, we have had no favorable opportunity to study the habits of the species in any of its stages further than to remark its abundance in the adult stage during May about low grounds on the prairies, particularly those of Illinois. There we have swept the beetles in great numbers at night from low, dwarfed examples of the two species of willow, *Salix discolor*, Mahl., and *S. petiolaris*, Sm., and have also found them in great abundance under the débris deposited by suddenly swollen streams which ran through low prairie land.

It will be observed that the three preventive measures, spring plowing, summer fallow, and fall plowing, all figure in the notes here given, showing that whatever virtue these measures may possess lies in their being applied at some particular time and in a particularly thorough manner.

REPORT UPON THE INSECTS OF THE SEASON IN IOWA.

By Prof. Herbert Osborn, *Special Agent.*

Ames, Iowa, *November* 30, 1887.

Sir: I herewith transmit to you my report of observations for the summer of 1887. I desire to express my thanks to you and your assistants for the determination of doubtful specimens, and for the many other favors which you have been so ready to grant.

Respectfully,

Herbert Osborn.

Prof. C. V. Riley,
U. S. Entomologist.

THE TURF WEB-WORM OR SOD-WORM.

(*Crambus exsiccatus*, Zeller, var.)

My attention was first called to this insect, which has proven a most serious pest the present season, by a note from Mr. Henry Barnes, who owns a farm near Gilbert, Story County. Under date of May 24 he writes:

Dear Sir: Inclosed I send you bottle, in which are some specimens of a worm that is making sad havoc with our sod-corn. They eat the stalk off beneath the surface and many of the leaves are punctured full of holes. In some parts of the field nearly every hill is infested with the "varmints." Can you tell us how long they are likely to continue their depredations, so we can tell whether it will pay us to replant? The land from which the specimens were taken was seeded down some eight years since, and was mainly blue grass and white clover. Has been used for a sheep pasture about six years. Was underdrained and broken up last fall and this spring, and planted to corn with the above result. Will be greatly obliged for any information you can give us on the subject, and should be pleased to hear from you as soon as you can make it convenient, so that in case you can suggest anything likely to relieve us of the pest or enable us to escape his work we may have time to avail ourselves of the knowledge.

Yours, respectfully,

Henry Barnes.

In reply I recommended replanting and stated briefly the probable history of the insect. This reply was published in the State Register, and shortly after the following letter was received:

Ossian, Iowa, *June* 9, 1887.

Sir: I have seen your answer to Mr. Barnes in the State Register of June 3. Now, my corn has been destroyed in precisely the same way. It was planted on the 8th

of May, and came up immediately and looked very nice, but it was taken in about two days, so that the field looked perfectly bare. We replanted on May 21. The corn came up very nice again; we have harrowed it and plowed once, but there will not be a hill in the field to-morrow night that will not be partially or wholly destroyed. This certainly can not be the same worm that is troubling Mr. Barnes, as they have been in my corn for three weeks, and I can not see any change in their appearance. As it is now too late to try corn again would it be safe to sow corn for fodder? The hay crop in this (Winneshiek) county is a failure, and this piece of ground has got to produce something. It was seeded to timothy and clover three years ago and has been used for hog pasture since that time. Inclosed find bottle containing specimens. Will be short of feed next winter and any advice or suggestion will be thankfully received.

Respectfully,

A. W. OXLEY.

To this I replied advising to put in corn and stating my belief that the adults were already issuing from the chrysalis state.*

Early in June I had noticed the striped ground-squirrels on the college lawn digging into the turf and eating something which they withdrew. Examining the places thus dug up I always found the peculiar cocoon of a Crambus, and the place would also show the deserted web and burrow of the larva. These squirrels' burrows were very numerous in some parts of the lawn, and in one place I counted twenty-five in the space of a square yard, indicating that the ground-squirrel has disposed of that many larvæ or pupæ of Crambus within the given area. At another time I counted fifty to a square yard. Evidently when sod-worms are plenty the ground-squirrel is not an unmixed evil.

I did not at first connect these worms with the ones referred to by Mr. Barnes, but comparisons of specimens of larvæ found in sod here with the imperfect specimens sent by Mr. Barnes, and later with those from Mr. Oxley, satisfied me that they were very probably identical. Subsequent observations made this almost a certainty. I have therefore dealt with them as belonging to the same species.

Evidently we must consider it under the double rôle of a grass pest and a corn pest, and while it certainly causes in the aggregate vastly more damage to grass than to corn its work is more noticeable on the latter crop, since it so completely destroys fields planted upon sod infested by the young worms.

Since this insect has assumed so great an importance to two staple crops, and as its life history and habits have been but partially recorded, I have devoted as much time as possible to a study of it the present season and will give the result of my studies in detail.

Its distribution and injury so far as the corn crop is concerned may be gleaned in part from the Iowa crop report, which has kindly been placed at my disposal by the secretary of the State Agricultural Society, Hon. J. R. Shaffer. Aside from the localities given in the following list there was considerable damage in this (Story) county, and, as stated by Mr. Oxley, in Winneshiek County.

Extracts from crop report.

BREMER COUNTY.—Corn on old ground injured by a small green worm.

CLINTON COUNTY.—Cut-worms injured corn on timothy sod and old pastures.

DAVIS COUNTY.—Corn on sod and fallow ground has been destroyed by Web-worms.

FAYETTE COUNTY.—Corn looking well, notwithstanding the severe drought: some planted on timothy sod injured by Cut-worms, but general stand good.

HENRY COUNTY.—Meadow-worms working at the roots of grass.

VAN BUREN COUNTY.—A worm resembling the Cut-worm has done serious damage to corn; it built a web in the hill and would eat whole fields planted on new ground.

JOHNSON COUNTY.—Cut-worms destroyed 25 per cent. of the corn planted on sod.

JONES COUNTY.—Corn two weeks ahead of last year. That replanted on account of Cut-worms is gaining on the other.

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*In answer to further inquiries as to results in these fields Mr. Barnes informs me that the replanted corn was not materially injured by the worms, and that taking drought and Chinch Bugs into account produced a very fair crop. He further says that the portion of his field most damaged was the part plowed in spring. Mr. Oxley states that the worms took three plantings for him, but that he then planted to fodder-corn and raised a most excellent crop; he says worms worked in this a little at first, he thinks as late as June 27, but did no serious damage.

POWESHIEK COUNTY.—Cut-worms are doing some damage to corn.

WARREN COUNTY.—Corn somewhat injured by grub and Cut-worms, but as a whole prospects were never better for a good crop.

APPANOOSE COUNTY.—Some sod worms; no material damage from them as yet.

CEDAR COUNTY.—Corn injured by Cut-worms, on sod ground much had to be replanted.

CLARK COUNTY —Corn damaged by Cut-worms.

DAVIS COUNTY.—Corn on sod taken by Cut-worms; many replanting the third time.

DELAWARE COUNTY.—Some timothy fields entirely destroyed by Cut-worms; many being plowed up and planted to corn.

JEFFERSON COUNTY.—Corn on old ground good, but is being destroyed by Cut-worms on timothy sod; much has been replanted.

JOHNSON COUNTY.—Corn a good stand, except that on timothy sod has been cut off by worms.

KEOKUK COUNTY.—Corn planted on sod injured by Cut-worms and much had to be replanted.

LEE COUNTY.—Corn generally good and forward for the season. New Web Wire-worm cut off most of the corn planted on sod plowed this spring.

POTTAWATTAMIE COUNTY —Cut-worms and ground moles doing some damage to corn, but generally it is a good stand and color.

VAN BUREN COUNTY.—Corn planted on timothy sod being replanted the third time, Cut-worms taking all corn planted on sod ground.

WAPELLO COUNTY.—Corn on sod ground had to be replanted.*

The extent of its ravages in meadows in other parts of the State I am unable to give with any precision. On the college farm, both on the campus and in the pastures and meadows, it has been very abundant and the grass has suffered seriously. In patches the damage was such that it has not recovered; while over large areas the grass being cut off above the crown has grown up rapidly since the fall rains. During the severe drought, which extended till the 1st of September, the damaged portions did not show plainly, as the whole surface was dried up, but after the rains such areas were much slower in becoming green. But that the damage was not due to dryness was evidenced by the greatest damage occurring in depressions or in places where there was the most moisture, instead of on the tops of the knolls or in specially dry places. On the line of the Northwestern Road from Ames to Clinton I saw in the latter part of August many meadows and pastures presenting the whitened patches indicative of the presence of this pest. Outside the State, in Illinois and Wisconsin, I found evidence of it wherever I went.

The insect is distributed widely over the country, and I doubt not has been destructive in all the Upper Mississippi Valley, though probably a large portion of the damage done by it has been ascribed to the drought or other causes.

The injury to corn results only from planting upon sod. As it is very desirable to make this transfer when the meadows have been severely injured it becomes of the utmost importance to the corn crop to avoid the damage done, which necessitates replanting and causes vexatious delay. The measures necessary to avoid this damage I believe to be simple and practicable, and they will be fully stated under the head of remedial measures.

Habits and life history.—Owing to the abundance of this species upon the college lawn I have had opportunity to observe it during the entire season in all stages, and though some points of interest remain to be studied, I am able to state the principal facts in regard to its life history. Enough I am confident has been determined to form a solid basis for recommendation of remedial measures.

During the last of May and fore part of June larvæ and pupæ were abundant, and were observed as late as June 10. On June 7 the moths were plenty, and June 9 they were flying to lights in the houses by thousands. They came to my study in swarms, and I was afterwards told by students that they gathered to the electric lights in the college building in such numbers as to seriously interfere with their work. On the morning of the 10th, having closed the windows of my study the night before to prevent the moths from escaping, I counted over one hundred moths at one window, and the window-sill, the sash, and the floor in front of the window were thickly strewed with their eggs. On slightly pressing the abdomen of a female with thumb and finger she extruded, one by one, thirty-five eggs, after which none were extruded by pressure, but upon dissection of the moth I found ninety well-formed ova and a large but uncertain number of formative stage in tubes of the ovary. As this was a captured female and she had had time during

*I have included in the above extracts those given as Cut-worms, etc., though some of these very likely may refer to other species than *C. exsiccatus*.

the night to dispose of eggs which I did not count, I could not determine the full number possible from a single individual, but from those counted and those partially formed in the ovary it seems perfectly safe to say that each female can deposit at least two hundred eggs. The eggs are yellowish-white, oval in shape, with usually fifteen longitudinal ridges. In a few instances I noticed more. When extruded they are held momentarily at the tip of the abdomen, giving them time to dry, so they do not adhere to any object upon which they drop, but before the extrusion of another egg are snapped sharply away by a contraction of the lips of the vulva, which appears to be armed with a row of minute bristles. Eggs in this way were thrown quite a distance, and when being deposited in grass would be sent well down among the dead leaves at the surface of the sod. In a few cases I noticed one egg remain till the next was extruded, and the two would adhere slightly, but doubtless the natural extrusion is not so rapid as that induced by pressure.

On June 11 the moths still shut up in my room had deposited eggs in greater numbers than the night before, and some of them confined in a glass jar had also deposited many.

The eggs collected on June 10 hatched on June 18, and I infer that fertilization of the females had taken place previous to their flying to light. A point which I did not carefully determine is the proportion of males to females in those gathering to lights, but my impression is that the females were largely in excess.

Some of these newly-hatched larvæ were placed in a jar with earth and fresh grass, others in a jar without earth, while still others were scattered over a small area of grass out of doors in a place convenient for observation. These last could not afterward be found at all and the grass showed no signs of their presence. Being in a very dry location and the grass becoming badly dried up I suspect they did not obtain sufficient moist food to enable them to start their growth. The young larvæ when supplied with fresh grass collected at the broken ends and fed with avidity. Their bodies, at first pale, became after feeding yellowish-green, the head and upper part of the first segment being black. On the 20th I noticed that one of the larvæ had formed a tube by drawing together the edges of a blade of grass, while still others had gone under the earth at bottom of jar. Unfortunately, duties that could not be postponed prevented attention to these larvæ and a few days later they were all dead. One, however, had formed a basket-work attached to blades of grass. This had probably been formed as early as June 25. By the middle of July the larvæ were becoming conspicuous by their ravages in corn, and subsequent observations were made either directly in the field or upon larvæ collected and confined. Notes for July 13 and 16 record larvæ numerous in part of one field of sod-corn confined to a portion of the field last plowed. As the time of plowing appeared to be an important item I obtained, through the kindness of Mr. F. S. Schoenleber, the exact dates of plowing of the fields planted to sod-corn. One field plowed 9th to 11th of May contained no turf web-worms and no signs of their work. Another field had been plowed in part May 12, 13, 15, and 18. The remaining central portion was plowed on the 7th and 8th of June. The portion first plowed was entirely free from injury by worms, while the part last plowed was badly infested. The line of separation between that first plowed and that last plowed was in some places distinctly indicated by the missing hills or damaged stalks, indicating the presence of worms. It seems reasonably certain, therefore, that Crambus eggs were deposited on the central part in the grass before the sod was turned June 7 and 8, and the larvæ hatching by the 15th to 18th of the month had no other resource than to attack the corn which came on shortly after. As already stated, Crambus adults were abundant June 7, and had doubtless been present in fewer numbers for several days, so there was opportunity for the eggs to be deposited on the grass land prior to the plowing June 7 and 8; while from the absence of worms in the other sod-corn it was evident that no eggs were laid on the ground plowed previous to the first of June. None have, with possibly one or two reported exceptions, ever been found in corn-fields except when planted on sod. The exceptions, if referring to this species, may probably be accounted for in other ways than by assuming eggs to be laid on plowed land.

In corn the young worms construct a web from half an inch to an inch below the surface of the ground, usually winding it irregularly among the roots and stalks of corn. Frequently a number of these worms occur in a single hill, but as a general rule only one or two are found well developed. Hills infested by these worms have the stalks when small cut partially or entirely off, sometimes, I judge, the upper portion being entirely devoured. Larger stalks have cavities gouged out of the sides at the surface of the ground and a little above. The leaves also are eaten at base and numerous holes scattered over the blade. Sometimes these holes are arranged with a peculiar regularity, occurring in transverse rows three to five holes in each row, and the rows about the length of the worm apart. The stalks at

the surface of the ground are sometimes blackened and decayed, and in some instances I thought I detected their work on the roots. Naturally they do not find food in such abundance as in grass and may be expected to take whatever they can most readily attack.

On July 20 larvæ were found in corn apparently full grown and ready to pupate. Specimens confined in a glass jar with a little earth matured, two adults issuing and first noticed August 3, both fresh and apparently but recently expanded. Larvæ were found in corn as late as August 9, and from these I had one adult issuing during my absence and first seen by Professor Hitchcock August 25.

In grass land the larvæ form a web-lined burrow about half an inch beneath the surface of the sod, extending as the larva grows to a distance of 4 or 5 inches, nearly straight, and opening at the surface of the sod. The grass above and surrounding these burrows is cut off just at the surface of the ground; and where the worms are plenty the grass cut off forms a complete mat, which can be drawn aside, exposing the burrows of the larvæ. By pushing up the sod along the burrow the web and worm are brought to view. The roots and usually the crown of the plants, except directly above the burrow, are unaffected, though from the failure of some patches to revive even six weeks after rains have entirely restored other parts of the lawn it would seem that in some spots the worms were so hard pressed for food as to eat down into the crown. August 4, and for a number of days thereafter, full-grown worms forming cocoons could be found in abundance, and gradually adults became more numerous, till in the middle part of August and until the fore part of September they were again abundant. They were swarming to lights August 11. From this on the adult decreased in number, and the last record I have of seeing them is October 3.

This is as far as I have made positive observations on the species, but it is probably safe to infer that the eggs laid in the fall hatch and the young larvæ establish themselves in burrows where they pass the winter and awake to resume feeding in the spring. By the latter part of May the bulk of this brood is full grown, and, as we have seen, the moths issue in swarms between the 7th and 20th of June.

The insect is double-brooded, though scattering moths may be seen as late as last of June for the spring brood and as early as first of August and late as fore part of October for the fall brood.

The life history, as I have observed it and supplying by inference the winter condition of one brood, may be summarized as follows:

Moths of the spring brood appear in June; early stragglers by the 1st, the bulk of the brood from the 7th to the 15th, and late stragglers till the 1st of July. These deposit eggs which hatch in eight days from time of deposition. The larvæ require from five to seven weeks to become full-grown, forming in the meantime a web-lined burrow in the sod, within a portion of which or in sod close by they form a cocoon and change to the pupa stage. The pupa stage is passed in from twelve to fifteen days, the fall brood of moths appearing in August, early stragglers the 1st of the month, the bulk of the brood during the middle of the month and till the 1st of September, and late stragglers are seen till fore part of October. Moths of this brood deposit eggs for the fall and winter brood of larvæ, which larvæ mature by the latter part of May, pupating during last of May and fore part of June. These produce the spring brood of moths which appears in early June and the cycle is complete.

Description of different stages.—Reference has already been made to the appearance of different stages, and technical descriptions of some of the stages in other publications makes it unnecessary to go into detail here. I may state in brief, however, the most striking characters, in order that the insect may be recognized by those interested. It may be said, however, that it so closely resembles other species of the same genus that except to the professional entomologist a separation is next to impossible. Differences in habit, however, will assist in distinguishing them.

The egg is .55^{mm} long and .30^{mm} in diameter. It is fluted or ribbed longitudinally, the ribs numbering usually 15, rarely 16 or more. They are yellowish white, becoming darker as they reach the time for hatching.

The larva when newly hatched is .70^{mm} to .75^{mm} in length. The body is pale, almost white, while the head and upper part of the first segment is dark brown or blackish. The body is provided with scattering fine hairs. When full-grown it is nine-tenths of an inch long when extended, of a light brownish color, the head and upper part of first segment darker, and the head blotched with blackish. The segments following the first have glassy, slightly elevated, darker spots, from which arise fine hairs.

The pupa is bright reddish brown, half an inch in length, the terminal part obtuse and blackish. It is inclosed in an elongate oval cocoon made of a thin web and covered with green frass, which looks much like bits of grass cut fine, and indeed they seem to be but partially digested. A cocoon formed in a glass jar from corn

leaves seemed to be cut and used entirely undigested, and I surmise the material is cut especially for this purpose and passes directly through the body, to be used on the cocoon.

The moth is of a light ashy color, and fresh specimens show two obscure oblique dark stripes passing from the hind border toward the apex on the front wings. The wings are folded closely around the body when at rest. The length of the body is about one-half inch, and the wings expand an inch and one-eighth to an inch and one-fourth.

Remedies.—Under this head we must treat separately the measures to be adopted for corn and meadows or pastures.

As corn is attacked only when planted on sod, the damage being done by larvæ hatching from eggs deposited in grass or by larvæ that have partly obtained their growth in grass, all methods of prevention should recognize the time at which eggs are deposited and the larvæ mature.

When the worms are already at work in the corn the cheapest and best method is probably to replant, for the larvæ must all or nearly all mature by the middle of June at latest, and then no further damage need be feared. Reports show that this practice was successful, though in many cases fields were planted the third time. It would be well in planting on sod plowed late in the fall before to delay planting as long as practicable, thus starving out the majority, at any rate, of the worms, and then, if necessary, replanting as soon as possible when hills show presence of worms. If possible, however, the plowing should be done early in the fall, so as to prevent the eggs being deposited, or if deposited to starve out the larvæ before they have prepared for their winter fast. To be most effectual the plowing should be done before the 1st of September, and if the land be meadow land not used for fall pasture it will be safest to plow as soon as possible after the crop is off. When the sod is to be plowed up in spring it should be deferred if worms are present till they begin to change to pupæ, or for this latitude till the middle of May, and should be done before the moths make their appearance, or by the 1st of June. Our notes show that here sod plowed in May remained entirely free from worms, while that plowed the second week in June, just after appearance of moths, was badly infested. If noticed when they first begin their work on corn it is probable that the use of bisulphide of carbon would effectually destroy them, but it is doubtful whether it would be as satisfactory as replanting. The worms are easily detected, since they are to be found in their webs in the day-time, and they can be picked out by hand quite rapidly, as I know from experience. Possibly boys could be employed to collect them with good profit. These methods should be resorted to only in cases where preventive measures have not been employed. But in this case prevention is so easy that there seems little need of trouble from the pest when its habits are understood.

In meadows badly infested and thereby run out one method to be adopted, where circumstances will permit, is to plow up the sod and plant to another crop; but to avoid damage to the new crop, especially corn, the sod should be turned before the 1st of June, if in the spring, and if in fall before the 1st of September. If, however, the plowing is done prior to the egg-laying either of spring or fall the moths will fly to such pastures and meadows as are left and concentrate there, thus causing greater damage. On this account some plan should be adopted to prevent, if possible, that source of damage. If the land can lie after plowing to starve the worms it will be a good plan to defer plowing till eggs are laid and then turn them under to starve. In fact, knowing the cycle of life in the insect, and the time at which eggs are laid and the worms hatch and mature, each cultivator can adapt his measures to the special circumstances of his particular field.

A plan by which to greatly lessen the number of moths and the injury resulting from their presence in meadows and pastures may be based upon their habit of congregating in such immense numbers to light. I have shown that the moths thus attracted are in large part at least the females loaded with eggs, and it is probable that they have deposited few eggs if any previous to their flying to the light. Hence every female moth captured means the destruction of from one to two hundred eggs at the least. As the moths come to light by thousands, I think I may say even by millions, within a square mile, it can be seen how important is their destruction. Hundreds of them perish as a result of their own self-destructive habit, but by taking advantage of this habit and placing lanterns over tubs or pans of water in exposed places where they may be seen considerable distances, hosts of moths may be captured and destroyed. A little kerosene on the water will make their destruction certain, as then, even if they succeed in crawling out over those already submerged, or at the sides of the tub, they are quite sure to have received enough oiling to kill them in a short time. A little care in killing those accumulating in houses will also assist in lessening their number. Where electric lights

are in use they may be utilized to especial advantage in the capture of thousands of moths. I see no feasible plan of attacking the larvæ after they are established in the turf.

Natural enemies.—I have already mentioned the fact that the pupæ, possibly the full-grown larvæ, are extensively preyed upon by the striped squirrel (*Spermophilus 13-lineatus*). Unfortunately this sprightly little rodent has a taste for other food, which has gained for it a very unsavory reputation as a farm adjunct. Doubtless where corn is cultivated the injury to that crop will overbalance the good they may do in meadows; but I am inclined to think that for land kept constantly in grass their value is far greater than usually supposed. I know they feed upon the seed of grass and clover and doubtless also to some extent on the leaves and stems, but they also feed on noxious weeds and insects.

During several years' close observation of them on a lawn I have failed to find any indication of serious damage to the turf, and could they be kept in bounds I should feel like recommending that for permanent lawns they be allowed a home for the sake of the insects they devour. They seemed to select the cocoons of the turf-worms infallibly, pouncing upon a certain spot, digging for an instant, and then sitting upright to devour the dainty morsel.

Other mention of the species and related forms.—In his first annual report as State entomologist of New York, pp. 149, 150, Prof. J. A. Lintner gives the result of a breeding of one larva of *Crambus exsiccatus* in connection with a detailed account of the *Crambus vulgivagellus*, and there expresses the suspicion that the insect is double-brooded.

In the fourteenth annual report of the State entomologist of Illinois, pp. 12–17, Prof. S. A. Forbes describes under the name of *Crambus zeellus*, Fernald, an insect which in many respects resembles the species here discussed. In some respects, however, there is considerable difference, and I have not attempted to determine the relationship between them. This species described by Professor Forbes is mentioned and a letter relating thereto is published in Bulletin No. 12, p. 33, Division of Entomology, United States Department of Agriculture.

I can not overlook the possibility that there may be more than one species included in the records here presented, and indeed for the reports from over the State there is every probability that two or more forms are included under the general name of sod-worms, web-worms, etc.

The occurrence of *Crambus vulgivagellus*, for instance, in company with *exsiccatus* would account for several apparent discrepancies in reports concerning the time of pupation of the Web-worm. It has been my effort to record the facts as observed and reported, and the distinction of the different species, if such be included, must be worked out in the future. There can be no question, however, that the great body of the swarm appearing here the present season belongs to one species.

THE WHEAT-HEAD ARMY-WORM.

(*Leucania albilinea*, Guen.)

An insect which can without doubt be referred to this species caused very considerable damage in some of the southeastern counties of the State. Unfortunately I was not aware of the damage till too late to secure specimens for determination. Descriptions of the larva and its work, however, are so characteristic that I feel confident it was this species. I subjoin extracts from the Iowa crop report for July 10, 1887, which will show the distribution and damage so far as reported.

It will be noticed that the area included extends from the Mississippi River to a little west of the middle of the State and comprises only the two southern rows of counties, with the exception of Adair, which corners to the northwest upon the last infested county in the second row. Estimates given for two of the counties place the loss at 75,000 bushels (equal to about $150,000) in one (Jefferson) and at $30,000 in the other (Wayne). It is possible that these estimates are too high, but if we cut them down one-half and suppose the other eleven counties reported to have suffered in like ratio it would make a total loss of over half a million dollars for the thirteen counties. Doubtful counties out of this area may have suffered more or less, but not so conspicuously as to attract attention. The moths were noted at Ames during the summer, but not in unusual abundance.

Extracts from Iowa crop report.

ADAIR COUNTY.—There is some new insect eating off timothy heads.

APPANOOSE COUNTY.—Timothy heads eaten off by worms. There will not be any seed in Franklin Township. Within the last fifteen days a worm looking like an overgrown measuring worm made its appearance on timothy heads and com-

pletely stripped many pieces, damaging the crop very much; they have disappeared. Timothy light, a small green worm eating off the heads. Timothy heads destroyed by a small green worm.

CLARKE COUNTY.—A worm working on timothy heads.

DAVIS COUNTY.—Worms are eating off timothy heads. Timothy heads eaten off by a peculiar green worm, name unknown. Timothy heads destroyed by a small green worm.

DECATUR COUNTY.—Green worms working on timothy heads. Worms have destroyed timothy heads. Green worms playing havoc with timothy heads. A worm has almost destroyed timothy heads.

DES MOINES COUNTY.—Timothy heads eaten off by a small green worm.

HENRY COUNTY—A light-green worm 1 inch long has done great damage to timothy heads. A green worm did some damage to timothy heads, but has disappeared. Meadow worms working at the root (of timothy) and a green worm about 1½ inches long, name unknown, working on the head. Timothy heads destroyed by worms. Timothy badly damaged by a small green worm eating the head. Timothy being cut to save it from worms.

JEFFERSON COUNTY.—Some worm working on timothy heads, stripping off chaff and seed and leaving stems naked. Timothy seed, of which this county usually ships about 75,000 bushels, will not exceed the wants of home consumption.

LEE COUNTY.—Timothy injured by a small worm eating off heads. A small green worm has done great damage to timothy heads and is working on oats. Timothy heads destroyed by worms.

LUCAS COUNTY.—A green worm has appeared on timothy heads and will materially lessen the seed crop. Bountiful rains June 10 to 18 promoted growth of timothy 10 per cent.; a worm from half to two inches long appeared about the same time and has devoured whole fields. They do their work principally at night. Timothy seed has been completely destroyed by myriads of green worms. A worm doing damage to timothy heads. A small green worm doing great damage to timothy heads.

RINGGOLD COUNTY.—Timothy will be a short crop in many fields; heads of timothy entirely eaten off by a green measuring worm. Grasshoppers and worms heading timothy; small green worm eating off timothy heads.

VAN BUREN COUNTY.—Timothy heads eaten off by worms. "Army-worms" are destroying timothy meadows. Timothy damaged by drought and a small green worm working on heads.

WAYNE COUNTY.—A worm, name unknown, cutting off timothy heads. Sod (of timothy) injured by spring drought and latterly a worm eating off the heads. There is a small green worm doing much damage to timothy heads. A worm three-quarters inch long is eating the timothy; will not be more than 10 per cent. of a crop, a loss of $30,000 to this county. Timothy heads destroyed by worm; timothy heads eaten by worms. A worm resembling a Cabbage-worm is destroying timothy heads. A small green worm eating timothy heads.

BLISTER BEETLES.

(*Lytta cinerea* and *Epicauta vittata.*)

Two species of these common beetles were unusually abundant this season, doing considerable damage to various plants, and in a number of instances causing quite serious blistering upon the faces and hands of people. I noticed an item in the daily paper to the effect that in a certain town in Missouri they were so plenty, flying into houses by night and producing such severe blisters, that people were obliged to avoid lighting lamps in the evening. Several of the college students suffered from blistered faces after handling the *cinerea*, and I was myself adorned for several days with a swollen face, having, as often before, gathered a number in my hand and probably while perspiring brushed some part against my face.

Lytta cinerea was the species first noted as abundant. June 7 and 8 it was plenty and stripping leaves of Honey Locust. June 9 I observed some of the beetles feeding upon clover, and that evening noted it attracted to my light. Specimens were received from Hancock County, where it was reported destructive, and it was also reported destructive to potatoes in Cerro Gordo County.

The Striped Blister beetle (*Epicauta vittata*) damaged some of the potato patches in and about Ames, and July 20 I noticed them plenty on injured corn, but as grasshoppers were present they may not have caused the damage. The following items from the crop report apply, most of them certainly, to this species, while some may apply to either this or the preceding species:

ADAMS COUNTY.—A long striped bug is eating potato vines.

CLARKE COUNTY.—Potatoes damaged by a long striped bug.

CLINTON COUNTY.—Flying potato-bugs threaten late potatoes. The Spanish Fly is very destructive to the potato crop.

HENRY COUNTY.—Potatoes have been badly eaten by the long striped bug.

JACKSON COUNTY.—A new species of potato-bug has appeared, but as yet no damage done.

JOHNSON COUNTY.—We have Colorado and two kinds of long bug, the latter headed off by Paris green. Army bugs are very bad on potatoes and corn. Colorado beetles appeared in small numbers and needed no attention, but the flying variety are extremely numerous and doing great damage to potato crop.

MONTGOMERY COUNTY.—A new variety of potato-bugs has appeared, doing great damage. They made their appearance June 8, and are equally destructive as the Colorado and far more difficult to destroy.

Many complaints have come to me that these Blister Beetles can not be killed with Paris green or London purple. This, I think, must be due to the insects traveling about so much, and thus leaving places that have been poisoned for their benefit. If care is taken to spray the whole patch, and especially parts not invaded by the pest, the result would, I think, be much more satisfactory. It should be remembered, too, that especially with London purple effects are not to be noted for from twenty-four to forty-eight hours after application. It should of course be remembered that in the larval stage these insects are beneficial, so that where they become destructive to some valuable crop, should they be destroyed?

THE FALSE CHINCH-BUG.

(*Nysius angustatus*, Uhler.)

The life history of this species, so far as I can find and as I have been informed by Professor Riley, who desired especial observations on the unknown points, has never been fully stated in that no record of the eggs or their place of deposition has been published.

As the species has been quite abundant here I undertook to determine this point, and in July, when adults were plenty and copulating, I made careful search in the ground around roots and among tbe leaves and blossoms of the common trailing Amaranth (*Amarantus blitoides*) where the insects were most abundant. My search was rewarded July 19 by the finding among blossoms of an egg which seemed reasonably certain to be the one sought, and careful comparison with eggs dissected from gravid females proved them to be identical.

The egg is slender, cylindrical, yellow, irregularly wrinkled, and tapering slightly at both ends. The smaller end is orange red. Evidently this is the head end and the orange-red color due to the eyes in process of formation. In eggs from dissected females this color is more diffused and less conspicuous. While eggs may doubtless be deposited elsewhere than upon the Amaranth this may with certainty be stated as one of the places of deposition, and in this locality this weed appears to be the chief food plant of the species. The cases recorded by Professor Riley, however (Mo. Rept., V, pp. 111–113), show that it may at times prove a serious pest. Where their destruction is desired it is evident that collecting and destroying the Amaranth during and after the time of egg deposition would be a preventive measure easy to apply.

A few pupæ and numerous adults, some of them copulating, were observed November 15. Probably these adults winter over to deposit eggs in the spring. I have not, however, seen the adult in the early spring. As the spring brood does not mature till July, and as observations have failed to show any brood maturing between this and late in fall we may consider that for this locality only two broods are produced annually.

On July 14 (evening) I took a number of examples and noted many others that had flown to lights in my house, passing through the mosquito netting that covered the windows.

NOTES ON MISCELLANEOUS INSECTS.

Crepidodera helxines was quite abundant in May and caused considerable damage to the leaves of Poplar and Laurel-leaf Willow. *Disonycha abbreviata* was found upon seedling plants of *Eleagnus*, and I was informed that it was seen eating the leaves. The plants were considerably damaged and no other insect likely to do the damage was present. None were seen after May 20, and no further damage to the plants was observed. *Haltica chalybea* was observed here for the first time on grapes. Adults were seen May 18 and larvæ appeared in June, but no serious damage resulted here. Farther south in the State they caused serious injury.

Anomœa laticlavia was abundant and (June 9) observed stripping leaves of Honey Locust. It fed particularly upon the young leaves on sprouts. Many were noticed *in coitu*, the male with antennæ kept fully extended, and body of male nearly at right angles to that of female. No eggs were found, and none were deposited by beetles in confinement, but those dissected from female were .65 to .70^{mm} long, .40^{mm} wide, oval, some slightly reniform, yellow, and smooth. Twenty-two were taken from one female.

Phyllotreta vittata quite abundant and injurious to cabbages. They were observed (June 28) very plenty on leaves above and below, and one plant was badly injured by their attacks on the stem just above ground. They were also quite plenty on Horse-radish leaves.

Diachus auratus was found (June 29) eating the blossoms of Red Clover and depositing its eggs in the clover heads. The egg is oval, light brown, and covered with minute irregular projections and short, spiny protuberances. The egg before extrusion is smooth, but while passing out is coated with a glutinous substance which hardens and forms the spiny coat. This coat is started upon the end first extruded, and the egg, during extrusion, is gradually rotated by means of the hind legs. This, I take it, is to bring each part of the surface under the openings of the glands secreting the glutinous substance. Looked at from the direction of the insect's abdomen the rotation was in same direction as hands of a watch, for those I observed. Eggs kept in a glass tube (inclosed June 29) were found hatched the morning of July 13. Some of the larvæ had crawled from their egg cases; others were within, except head and legs, and drawing case about with them. Larvæ have the head reddish and the body and legs white. I attempted to feed these on fresh clover heads, but did not succeed.

Alydus eurinus has become quite abundant during past two or three years and occurs quite commonly upon Red Clover. July 21 I watched one closely for some time to see if it fed upon the clover, being careful not to disturb it, as they fly very quickly on approach of danger. It could be seen inserting its beak occasionally, then gradually withdrawing it, and to all appearance feeding. Examination of the clover head showed no insects, except a few larvæ of *Phœlothrips nigra* and one larva of *Anthocoris insidiosus*, none of which showed any signs of injury. The *Alydus* could not have been feeding upon them. The habits of allied species would favor the vegetable diet, and I believe it may be added to the long list of clover pests.

Anthocoris insidiosus, a well-known species, has heretofore been credited with preying upon certain noxious insects, and this summer, finding them plenty in clover-heads with *Phlœothrips nigra*, I tested its relation to this species by placing (June 29) one of the pupæ in a glass tube with a number of adults and larvæ of the latter species. In a very few minutes it had red larva impaled and quickly sucked out the liquid contents of its body, so that it was shrunken to simply a head, terminal segment, and legs. On June 30 I placed an adult *A. insidiosus* in tube with clover plant-lice of different sizes and with adult *Phlœothrips nigra*. It made no attack upon the other insects at the time, and on July 1 had not eaten any that I could determine. Some of the plant-lice had molted, and this I concluded would account for all shrunken skins present. On July 2 the plant-lice were all dead, only shrunken skins remaining, while the *Anthocoris* was still active. It seems probable that the plant-lice were eaten by the bug, since being supplied with fresh food they might be expected to survive more than forty-eight hours. I also saw the *Anthocoris* inserting beak into tissues of fresh clover blossom. It did not attack the adult thrips.

Piesma cinerea.—The Ash-grey Leaf-bug occurred the past summer in great numbers, but was not observed as abundant on any but noxious plants. A very few were noticed in spring on Grape but no damage to be seen. The same may be said of their occurrence on Plum. July 1 they were noticed in great numbers on *Amarantus retroflexus* (Pigweed or Amaranth), mostly paired, and on the under surface of leaves were numerous eggs, which I took to be of this species. This I proved by confining adults and securing eggs, and further by watching development of larvæ. A very few young larvæ were also noted at this time. The eggs are yellow, elongate, slightly bent, with about ten longitudinal ribs, the head end cut square off, and the red eyes showing plainly in eggs nearly ready to hatch. The larvæ when first hatched are two-thirds of a millimeter in length and a fourth of a millimeter in width, the antennæ four-jointed, the eyes red, and a red spot showing very plainly in the abdomen. By July 12 many larvæ on the plants observed were over half-grown, being at this time green in color. July 19 all stages were abundant, but many in pupa stage and many adults apparently fresh from the pupa stage with the wings delicate, almost white, and the body throughout green, except the red eyes. Two pairs apparently recently-issued adults were noticed *in coitu*. The green color is evidently retained for some time after reach-

ing the adult stage. This species was also observed, though less abundant on *Amarantus blitoides*,

Erythroneura vitis was abundant throughout the season, as also *Thrips tritici*, and *Phlœothrips nigra* was present in immense numbers in clover blossoms, both as larvæ and adults, and I think there can be no question but that they get their nourishment from the plant. There seems, however, to be no very decided injury as a result of their presence, though it is to be noted that many clover heads where they are present blacken early and do not set seed apparently as full as they should. I have seen adults of the latter species working their jaws rapidly on the tissues of clover blossoms, but could not discover any of the tissue bitten away.

Tetranychus telarius.—In addition to the usual plants infested by this mite I have observed it this season in egg, larval, and adult stages upon the leaves of clover, their presence being indicated by the usual yellowish or rusty blotches.

REPORT ON THE SEASON'S OBSERVATIONS IN NEBRASKA.

By LAWRENCE BRUNER, *Special Agent.*

WEST POINT, NEBR., *October* 24, 1887.

SIR: Herewith is submitted a report of my observations in the State of Nebraska and adjoining regions during the current year, being incidental to our conjoint work on the *Acrididœ*.

Very respectfully,

LAWRENCE BRUNER.

Prof. C. V. RILEY,
U. S. Entomologist.

INTRODUCTION.

The present has been an uncommonly favorable year for nearly every species of injurious insect that is thus far known to occur within the borders of Nebraska and adjoining States. A close, rather severe winter, followed by a moderately late spring without rains and changing to a hot, dry summer, has been the chief cause for this undue increase of noxious insects.

Among the insect depredators that have come to my immediate notice during the year the following are chief:

Chinch Bug, Codling Moth, Strawberry Crown-borer, Cottonwood Leaf Beetle, Colorado Potato Beetle, Cabbage Butterflies, Willow Sawfly, Ash Sawfly, Walnut Caterpillar, Corn Worms, Cut-worms, Larva of Swallow-tail Butterfly on Ash, Weevils in seeds of Ash, several species of locusts, native and migratory, and three or four species of beetles on the native willows.

COLORADO POTATO BEETLE.

(*Doryphora* 10-*lineata.*)

This beetle began operations rather later than usual, from which fact I had anticipated a year of comparative immunity from its ravages, which fact, I think, was mentioned in one of my letters to you at the time. During June, however, potato-fields began to suffer, and picking after picking of the mature insects appeared to make no impression on their steadily increasing numbers. Paris green and London purple alone saved such portion of the crop as was saved. Not until quite late in June and the early part of July did its natural enemies appear to be able to accomplish anything perceptible in the way of checking its rapid increase. This state of affairs was the general rule. In my garden, however, the crop was more favored, scarcely a beetle appearing until after the plants were all in blossom, and the first brood of the season made its appearance. From this time on they came in "swarms," and picking by hand availed but little. Soon the vines were covered and the leaves disappeared as if by magic. Now came the enemies, also quite numerous. various species of Lady-birds, Carabidæ, and two species of Hemiptera (*Arma spinosa*, Dallas, and *Perillus claudus*, Say), the latter not heretofore known by me to feed upon this insect. In fact I never saw it before that I remember of. When digging

potatoes about a month ago I saw at least fifty of them on a piece of ground about 20 by 40 feet in size, in different stages of growth, ranging in size from 2^{mm} in length up to the fully matured insects, which are from 8^{mm} to 9^{mm} in length. Since that time I have seen one or more daily creeping along the outside of the house or along the window and door screens. Only the mature insects were observed in the act of devouring the beetle larvæ.

This undue increase in the Colorado Potato Beetle is attributed to the long-continued and excessive drought with which this section had been visited. During the past three months we have had ample rains, and the result had been the almost immediate disappearance of the pest, which had just begun work on the tomato and various other solanaceous plants when the rains came.

CHINCH BUG.

(*Blissus leucopterus.*)

Great and wide-spread have been the depredations of this repulsive pest, which next to the Rocky Mountain Locust is our most injurious species of insect enemy. From its depredations alone throughout the drought-stricken region of the Mississippi and Missouri valleys, during the present season many millions of dollars' worth of grain have been destroyed, and in several localities actual privation is liable to follow.

The annexed crop reports, culled from various daily and weekly newspapers published throughout this region, will give a slight intimation as to the true state of the subject under consideration. Still, each region always draws its own afflictions as mildly as possible, while in speaking of those of a neighboring district they are liable to be somewhat overdrawn or exaggerated.

About the beginning of the second week in July rumors of Chinch-bug depredations at isolated localities throughout the drought-stricken area were first circulating through the press. A week later these rumors had become substantiated, and it was definitely known that their distribution and depredations were more wide-spread and general than was at first supposed; not only in this State, but also in Kansas, Missouri, Iowa, portions of Illinois, Minnesota, and southeastern Dakota. But not until harvest arrived was the full extent of their depredations known.

Causes of increase.—When the matter is carefully studied and the causes of the undue increase of this insect are taken into consideration the wonder is that the injury was not greater and more wide-spread than it actually has been. The long-continued drought of last year, with large areas of Chinch-bug depredations, followed by a generally close and rather severe winter, after which came a warm, dry spring and hot, scorching summer; all these favored in the greatest degree the most complete development of the bug in all its stages. But comparatively few of its natural enemies were present; and most of these, too, being species that prefer preying upon other insects to feeding on the unsavory rebel under consideration when they can be found. These predatory species had a plentiful host in the various species of Aphids, leaf beetles, and such like other depredators that were also present in great numbers.

One of the common and perhaps by far the chiefest of reasons for the large numbers of the pest that are always ready to take place whenever the advantage offers is the great carelessness of farmers in general to "clean up" during late fall and early spring. Especially is this true in portions of Nebraska, Iowa, and Kansas. The bugs winter among rubbish of all kinds, in meadows, along fences, in brush heaps, among fallen leaves, and among the débris collected by hedges, weed patches, and along the outskirts of groves among the underbrush. But there is no use of my going over these points that have been mentioned again and again by all writers upon the subject.

After the bugs have become a pest, the only effectual remedy is wet, cool weather. For some reason or other their constitution is not suited to a superfluity of moisture, nor can they adapt themselves to it. Humidity has the effect of bringing on disease and final dissolution with them, just as it does with various migratory locusts, the only difference being in favor of the locusts. A good, soaking rain, or at most two or three of such, following in the course of several days, generally ends effectually the most threatening Chinch-bug devastation, while on the other hand a year or even two of such weather are sometimes required to entirely obliterate a locust plague.

The question, then, naturally comes up, can this insect not be materially kept in check by some other and natural means? My answer to this question is, yes; to a certain degree, this is quite possible, and not nearly so difficult a task as one might suppose. A good cleaning up and burning of rubbish of all kinds in late fall, winter, or early spring, will answer the purpose, if the work be general, by reducing the number of hibernating insects. Osage orange and all other very brushy hedges are

the most attractive retreats, and at the same time most formidable retreats to master. For my part, I would be in favor of removing these and replacing them with some other kind not so difficult to keep free from the collecting débris carried by winds. Uncultivated prairie lands adjoining fields should also be burned early in spring. The breaking down and burning of corn-stalks in spring following a Chinch Bug year will also destroy myriads of the insects that have hibernated between the leaves and stalks. At other times, however, the stalks had better be utilized as manure by plowing under. If covered deeply, this will be a remedy fully as effectual as if burned. Protect the birds, and above all the quails, for they destroy countless numbers of hibernating insects of various kinds that are to be picked up about hedges and such like resorts frequented by these birds throughout the year. Although belonging to the granivorous birds, the quail is essentially insectivorous, except during inclement weather, when insects are not easily obtained. In my profession as taxidermist I have dissected many different species of birds, in the crops of which were contained injurious insects of various kinds, the Chinch Bug among the others. In no other instance do I remember of the presence of this insect in the crop of a bird in so great numbers as in that of the quail. As a rule, but few birds, mammals, reptiles, or rapacious insects seem to relish any of the odoriferous members of the order Hemiptera or true bugs. In winter, however, this repugnance is partially overcome, and now and then even a Chinch Bug seems a delicate morsel when "meat" is scarce.

Very few insects are known to prey upon the Chinch Bug; while I, myself, have never observed any of the species which have been credited with the good work—this attacking the enemy. True, I have frequently seen different species of Lady-bugs (*Coccinella*, *Hippodamia*, etc.), and the Lace-wing fly upon the same corn-stalk with the Chinch Bugs. Upon close observation it was also ascertained that the plant was more or less infested with some Aphid or plant louse which had attracted these, their natural enemies, before the other bugs arrived. It must not be inferred from what I say here that I discredit the writings of such authorities as Thomas, LeBaron, and others. Such is far from my intention.

Various remedies, as plowing, rolling, ditching, fencing, and the use of insecticides have been suggested and used with more or less favorable results, both in this and other States; deep plowing immediately after harvest having succeeded in a few instances by covering the bugs so deeply that they could not creep out. Rolling at a like season has crushed large numbers, while ditching and fencing have succeeded in "bunching" them, and for a time checking their onward movement while migrating from small-grain fields to corn-fields. At such times the dragging forward and backward of a heavy weight of some sort has been the means of causing great slaughter among their continually increasing ranks. Ditches into which water could be turned have formed complete barriers to their creeping migrations, but not to the after movements of the winged insects as they were about to mate for the second brood.

This insect, like all other depredators, has its likes and dislikes, and chooses its food-plants with considerable daintiness of taste.

The small grains are the first on the list, after which follow some of the grasses and corn. Among the grasses Millet, Hungarian, and Fox-tail stand at the head, while a few others that usually grow as weeds follow closely. Wild Buckwheat is also quite a delicacy with them, and I have noticed several examples where weedy fields were less injured than clean ones, notwithstanding the fact that the one contained equally as many bugs as the other. Several farmers in this country have also mentioned the same fact to me. As a rule, grain in a grassy field has the disadvantage alongside of that growing in a clean one. During the past summer I saw several examples in which the scale was turned. One of these in particular attracted my attention at the time. The crop was corn, growing just across a road from a field of wheat which had been so badly damaged as to render its harvest useless. The ground was covered with wild Hungarian or Fox-tail grass which at the time, August 6, was dead and perfectly dry for a considerable distance in from the road. Upon examination it was found that our old acquaintance was at work here, attacking the Fox-tail in preference to the corn. Referring to my notes made on the ground, I find the following:

"The Chinch Bug is still present in considerable numbers in a few corn-fields, but absent from others where there are signs of its work. In these a large per cent. of the grass (Fox-tail) has been entirely killed before the corn was attacked. In no instance has the corn been greatly damaged, the only perceptible injury being in the drying up of a few of the lower leaves."

We had several heavy rains just prior to this, so the partial disappearance of the pest could very likely be attributed to that cause. Since that date but a few scattered specimens of the bugs have been noticed. Hence, I imagine our rains of August and September have been of great benefit in their diminution.

In conclusion, I would state that the only remedy that I know of is in clean farming—burning all rubbish in early spring that has not disappeared during fall and winter; also the protection of our winter birds.

In regions that depend entirely upon irrigation for moisture, or such that are easily flooded, there never need be any loss of crops from the depredations of this insect.

As to future possibilities of injury we can say nothing definite, as weather alone will decide the matter, a wet year preventing and a dry one favoring their increase in damaging numbers.

LOCUSTS (grasshoppers).

During the month of June reports of the ravages of our old enemy, the Rocky Mountain Locust (*Melanoplus spretus*, Thos.), in one or two localities in the Northwest were going the rounds of the press, especially Eastern papers. Just what these ravages amounted to I am unable to state, not having been upon the ground. Neither am I prepared to predict anything in reference to their numbers and probable whereabouts for the future. That this insect was on the increase two years ago, when I last visited the region in question, I am positive. From the occasional references to their appearance at widely-separated localities since, and the frequent scattering flights observed to pass over this locality, both during the summer and early fall of 1886 and the present season, I am pretty certain their numbers have not decreased.

The Ottertail County, Minn., visitation is evidently more familiar to you than to myself; therefore I merely add the newspaper clippings referring to it that have come to my notice.

A few *spretus* alighted here about the middle of June, which arrived from the south. Others appeared July 10 to 12 from the north, and still others were seen in the air during the latter part of July and up to the 20th of August, the latter also moving southward, either from north-northeast or northwest. At no time were these flights what would be called large; still, when taken together, the numbers that passed would have comprised quite an extensive swarm. The only ones that were observed to deposit eggs were those which came in July, just before the harvest had fairly begun. From these there will be no danger next year, as their numbers were too few.

On account of the severe drought during the last and the present year, the various species of native locusts have become exceedingly numerous in some localities, where they congregated from the surrounding prairies in such great numbers as to materially injure the outer edges of grain-fields, as well as to clean out many gardens. On the 12th of July, while out on the uplands, 3 to 4 miles east of town, I found these "natives" in large numbers in the ravines or low places where the grasses were still green, as well as along the edges of grain-fields. They had congregated from the adjoining higher grounds, upon which the grasses had dried up and withered.

Melanoplus angustipennis, Dodge, which only a few years ago was quite rare and confined to the lowlands along the Elkhorn, is now becoming quite numerous. If the species continues to increase as rapidly during the succeeding four or five years as it has during the past few, it will be equally as destructive as *femur-rubrum*, *devastator*, *atlanis*, and *differentialis*. When first described it seemed to be confined almost exclusively to *Artemesia ludoviciana* as a food-plant. Now it seems to take to almost any food-plant that presents itself. This Narrow-winged Locust is more nearly related to *M. devastator* than to any of our other especially injurious species. Should it really become a pest, as present indications would suggest, its "arboreal" habit of living to a very great extent above the surface of the ground upon the stems and leaves of plants renders it rather a difficult enemy with which to deal.

Stenobothrus œqualis, Scudd.—At about 4 o'clock p.m. July 18, while walking through an orchard, I noticed several small grasshoppers spring into the air and start off on a flight, seemingly unmolested or unconcerned as to time of re-alighting. These locusts were so much smaller than any of the species heretofore observed by me to act in this manner that I decided upon an investigation. I accordingly watched for others as they arose and sailed joyously aloft, when one chanced to drift within reach of my net and thus suddenly ended his anticipated spree. Imagine my astonishment when the capture was ascertained to be a specimen of our common *Stenobothrus œqualis*, of the form approaching *St. maculipennis*. Further inquiry confirmed the fact that the recent capture was really one of many of these locusts that had actually decided upon a journey, and were on a move southwestward. By the aid of a field-glass it was estimated that some of these small locusts actually attained an altitude of upwards of 400 feet above the surface, while still higher were to be seen the larger specimens of *M. spretus*, of which a few were passing in the same direction.

The *Stenobothri* can be distinguished in flight from the former by their much smaller size and more slender form and by their more rapid-moving wings. They also fly with their body more nearly horizontal than do the various species of *Melanoplus* and *Camnula pellucida*.

I do not suppose that the flights of this locust as observed to-day are so extended nor so frequent as they are with the species which have heretofore been observed to migrate. Nevertheless, that there was a true migration in this instance I do not doubt. It may be argued that their leaving the stubble-field (for such it was where this action was first observed) was a necessity, and could have been accomplished in no other way. Be that as it may, there were others in the air enough higher to have come from considerably beyond the confines of the small field in question. Besides, they were seen from other localities later in the afternoon. The wind at the time was gentle, possibly 6 to 8 miles an hour.

My impression is that many more of the Acrididæ, as well as other members of the order, are at times migratory. Besides these *Stenobothri*, I also observed during August and September a similar movement among the long-winged variety of *Nemobius bivittatus* and *Œcanthus nigricornis*. These latter were leaving a recently-mown meadow, upon which the grass was still green. They also rose to a height of several hundreds of feet, and drifted with the wind in a similar manner to that employed by the migratory locusts. Nor did they alight immediately after crossing the intervening meadow, but kept steadily onward as far as the eye could follow them. Of these crickets at least two dozen, divided about equally between the two species, were noticed on the move. I only remained in the meadow about one hour, during which time I was collecting.

CABBAGE INSECTS.

Both the Rape and Southern Cabbage butterflies were quite numerous during the summer, and their larvæ did considerable injury to cabbages throughout this portion of the State. When compared with last year, I think the southern species (*Pieris oleracea*) was present in larger numbers this, while the Rape Butterfly (*P. rapæ*) was fewer than then.

I observed *oleracea* to be more partial to the pepper grasses than to cabbages. It also deposited eggs upon various cruciferous plants growing both in the garden and about the house. The *rapæ*, on the other hand, stuck to the cabbages, kahl, and rape, the latter of which grows promiscuously over the fields as weeds throughout the country.

Besides the larvæ of these two butterflies I also observed the small larvæ of *Plutella cruciferarum* in considerable numbers during the earlier part of the season. During August and September but few of them were seen.

The cabbage-louse, generally called mildew, was also very numerous and caused some little damage in a few localities during August and the first week in September. The same insect also attacked two of my melon vines and a small patch of sweet corn, but were soon mastered by the lady-bugs, which flocked in by the hundreds.

THE CODLING MOTH.

(*Carpocapsa pomonella.*)

This insect is becoming so numerous and destructive that comparatively few apples escape without a worm or two. In several orchards that I have examined during the season the finding of a perfect apple was rather more of a "chore" than one would suppose might be the case in a new country where apples have been raised but three or four years, and that, too, in rather small quantities. Either the moths must migrate in large numbers, or else this insect also infests some native plant. I have often found similar larvæ in both rose-buds and the thorn apple. Whether these were those of *Carpocapsa* or belonged to some other genus I do not know, as I have never tried to breed them. I do not think the increase of our Apple moth has occurred entirely at home, for but few apples go to waste, even the "windfalls" being utilized in almost all cases.

FOREST-TREE INSECTS.

Among the insects that have been more or less injurious during the past summer the following species were most conspicuous:

Affecting the Ash, larva of *Papilio turnus*, *Monophadnus barda*, *Thysanocnemis helvolus*, and *T. fraxini*. The *Papilio* larvæ have been exceedingly numer-

ous and destructive in portions of Antelope County, this State, upon the small trees planted and growing on "tree claims." A Mr. Copeland tells me of several instances where parties who had planted ash trees failed in proving up on their claims on account of the ravages of this insect. About equally destructive and by far much more numerous is the larvæ of the Ash Saw-fly (*Monophadnus barda*, Say). This insect also infests the same district, where it also kills many trees by repeatedly stripping them of their foliage. The larvæ of this Saw-fly are whitish and feed in company in a similar manner to that of several other species. I have seen upwards of a dozen of them upon the upper surface of a single leaf.

Kerosene emulsion would be an effectual remedy against both of these insects.

I have for several years past noticed that some insect works in the seeds of our ash trees often to such an extent that fully half of the seed upon a tree has been injured. This, in a wooded country, would be of but little or no importance. Out here, however, where we depend upon the few natural groves that are growing along our streams to furnish seeds for the planting of the thousands of tree claims scattered over our treeless prairies, we soon discover the loss of seed. The present summer I found the two weevils *Thysanocnemis helvolus* and *T. fraxini* to be the depredators.

Another insect which appears to be greatly on the increase in Nebraska is *Datana angusii*, G. and R., known out here as the Walnut Caterpillar. This insect has for the past four or five years been more or less injurious to our planted groves of black walnut. This year, however, it was quite abundant, and at three or four places completely defoliated a large per cent. of the trees. On father's place, adjoining town, there were at least 50 trees thus stripped. The first worms appear sometimes during the early part of July, and from that time on until the beginning of October. Whether there are more than a single brood each year, or whether their appearance is irregular, I can not say. Unlike some of the other species of the genus, this insect appears to be remarkably free from the attacks of parasites of all kinds. At least this has been my experience with it, never having found a single larva that showed any signs of being parasitized. The only birds that I ever saw eating it were the Cuckoos, both the yellow and black-billed species.

Where the trees are not too tall, and time allows, hand-picking will answer admirably in disposing of this and allied species. During the third to last molts the larvæ congregate on the trunk and can be easily taken, their black bodies clothed with the scattered long white hairs, making them quite prominent objects whether in the foliage or upon the bark of the tree. Their gregarious habit also renders them more conspicuous and the more readily observed on account of their taking the foliage clean as they go.

The Honey Locust, which is used as a hedge-tree in portions of Nebraska, suffers greatly while yet small from the attacks of the gray Blister-beetle (*Lytta cinerea*). I have seen the trees defoliated in a few days. This present year but little injury occurred in the immediate vicinity of West Point, but up in Holt County trees that were set out last year were completely denuded, the beetles in some instances almost covering the entire tree, so numerous were they.

This tree also suffers greatly from the attacks of a Tortricid, the larvæ of which spins together several leaves at night and feeds upon the adjoining ones. This insect, too, occasionally becomes sufficiently numerous to defoliate trees. Last year a piece of hedge, here at West Point, over 100 feet in length, suffered in this respect.

THE AMERICAN CIMBEX.

(*Cimbex americana.*)

This large slug-like larva feeds upon the White Willow, usually used for a hedge tree and wind-breaks about buildings. A few years ago I first noticed it in injurious numbers on the hedges of Willow in Dodge County, about 16 miles southwest of here. This summer again I was surprised to see it in very many new localities, both in this and Dodge Counties. It always appears upon rather elevated ground back from the Elkhorn and tributaries.

Referring to my notes of July 22 in reference to this insect I find the following: "To-day I visited several localities only to find at least one-half of the larvæ matured and transformed. In scraping away the leaves and other vegetable débris from underneath the trees it was found that the grubs invariably sought the sheltered or sunny side of the hedge before spinning in. They also appear to be gregarious in this stage, always congregating into groups of from two or three to two dozen or more. Their transformation takes place only one-half or three-fourths of an inch below the surface."

Out of upwards of 400 pupæ that I collected I failed thus far to rear a single parasite. Of course these, if there are any, may not mature until next spring at the time when the imagos of the Saw-flies issue. Birds do not appear to feed upon them, neither will domestic fowls.

As a remedy against their rapid increase I would suggest the clearing away of all rubbish from beneath the hedge soon after the last worms have disappeared. This can be done with an ordinary garden rake. The rubbish should then be burned. A good method would be the supplying of an artificial retreat for the larvæ, composed of finely-cut or broken straw as a mulching, which could be easily removed and afterwards burned.

This insect has always occurred here in moderate numbers upon the willows growing along the smaller streams; and upon the introduction of the planted trees with the more favorable retreats has succeeded in becoming numerous and at the same time one of our dreaded insect enemies.

OTHER INSECTS.

Besides the above-named insects, the willows and cottonwoods in this and adjoining States suffer greatly from the continued attacks of the Striped Cottonwood Beetle (*Plagiodera scripta*). This beetle was again exceedingly numerous and destructive in this and several other counties in this portion of the State. While large trees and those on low ground seldom suffer greatly from their attacks, small trees, and especially those growing upon elevated grounds away from streams, are often killed by them.

Their natural enemies are chiefly those that are known to destroy the Colorado Potato Beetle (*D. 10-lineata*). Among these enemies the various species of Ladybirds are chief.

Several species of *Chrysomela* and *Disonycha* have also been quite numerous during the season just passed. These worked upon the foliage of several kinds of willow growing along the Elkhorn. They also were sufficiently numerous in many isolated localities to entirely defoliate the trees.

Last, but not least to be dreaded, is the Strawberry Crown-borer (*Tyloderma fragariæ*, Riley). This insect has been gradually on the increase throughout eastern Nebraska during the past few years, until now it has come to be recognized as one of our insect enemies. It not only attacks the tame varieties, but also works upon the wild vines. During the past summer I noticed it at work in a number of strawberry beds in this immediate vicinity, in one instance almost entirely destroying a large bed of several thousand plants, which the owner thought resulted from drought alone. It chose the Wilson in preference to the Crescent Seedling upon which to work, at least three times as many of the former than of the latter being destroyed.

There were many other insects belonging to the various orders that were observed to injure crops and useful vegetation. These, however, were in rather limited numbers and their injuries of comparatively little importance, and I do not think it necessary to make mention of them at the present time.

REPORT ON EXPERIMENTS IN APICULTURE.

By N. W. McLain, *Apicultural Agent.*

DECEMBER 31, 1887.

SIR: I have the honor to submit herewith my report of the work done under your instructions at this experiment station during the past year, the main features of which consist of a further prosecution of those lines of research begun in the year 1886.

I desire to acknowledge my obligations to yourself for the helpful assistance and encouragement you have given me while prosecuting my work under most discouraging circumstances; reference being had to the unparalleled climatic conditions prevailing throughout this region during the past year, and also to the altogether inadequate financial resources available for the uses of the station.

I wish also to thankfully acknowledge the valuable services and suggestions of those who have aided willingly in some lines of investigation, as well as the uniformly kind and appreciative mention of my efforts by those in whose behalf the work is being done.

It is further a pleasant duty for me to acquaint you with the fact that the Bee-Keepers' Association of North America, as well as some of the State bee-keepers' associations, have passed resolutions thanking in appropriate terms the honorable Commissioner of Agriculture and yourself for the deep interest you have manifested in advancing and developing the industry of bee-keeping.

I am also under continued obligations to the publishers of many apicultural and agricultural journals for the favor shown in pu lishing my reports, and for files of their valuable papers, among which I would mention:

The American Bee Journal, Messrs. Thomas G. Newman & Son, Chicago, Ill.; Gleanings in Bee Culture, Mr. A. I. Root, Medina, Ohio; The American Apiculturist, Mr. Henry Alley, Wenham, Mass.; The Canadian Bee Journal, The D. A. Jones Company, Beeton, Ontario; The Bee-Keeper's Guide, Mr. A. G. Hill, Kendallville, Ind.; The Bee-Keeper's Magazine, Messrs. Aspinwall & Treadwell, Barrytown-on-Hudson, N. Y.; The Bee-Keeper's Advance, Messrs. Mason & Sons, Mechanics Falls, Me.; The Cultivator and Country Gentleman, Messrs. L. Tucker & Son, Albany, N. Y.; The Southern Cultivator, Atlanta, Ga.; The Canadian Honey Producer, Mr. B. Holterman, Brantford, Ontario, Canada, etc.

Yours, very truly,

N. W. McLAIN.

Dr. C. V. RILEY,
U. S. Entomologist.

DISEASES OF BEES.

The study of some forms of disease to which bees are subject, including an inquiry into the causes of disease, and the discovery and application of suitable remedies, has occupied much time, and the results from this line of investigation have been in a good degree successful and satisfactory.

The excellent classification and complete history which have been given of the micro-parasitical forms which affect the life and health of bees simplify diagnosis and facilitate the discovery and application of preventives and cures. Modern science has shown that it is often necessary to unlearn much of what was supposed to have passed beyond the region of doubt. The subject in hand furnishes no exception. It is not strange that there should be confusion and error in dealing with the origin and habits of these micro-organisms which baffle the skill of the investigator. We are now collecting and tabulating data and testing theories in the crucible of experience, and while our investigations are incomplete and many seemingly determined facts lack full confirmation, and while significant manifestations await interpretation, we must be slow in reaching conclusions. We may indeed be in the region of the knowledge we seek after, but we must hold the evidence under survey until many-sided experience fully determines its value.

Bacillus alvei (Cheshire).

This disease, commonly but inappropriately called foul-brood, is indigenous in all parts of the United States, and is infectious and virulent to the last degree. Concerning the origin of *Bacillus* and other allied organisms but little is certainly known, but that the organism classified as *Bacillus alvei* is the active agent in the destruction of both bees and brood is certain, for this agent is always present, and although its action in the living organism is exceedingly complicated it is also well defined.

The symptoms of this disease may be more clearly described by contrasting the appearance of bees' brood and combs in a healthy colony with the diagnostic symptoms attending *Bacillus alvei.* The bees act as if discontented and discouraged; the combs commonly present a dingy, neglected, and untidy appearance, and a characteristic odor is present, sometimes not noticeable until the hive-cover is removed, at other times offensive at some distance from the hive. This odor is very like that emitted from glue which has been prepared for use, then put aside and allowed to ferment. Instead of the plump, white, smooth appearance common to healthy uncapped larvæ, the membranes more or less wrinkled and shrunken, are streaked with yellow, which with the succeeding stages of disease changes into a dingy gray brown; then as putrefaction follows the color becomes a dirty red-brown. As evaporation progresses the mass settles to the lower side of the cell, and if the head of a pin be drawn through the mass, that which adheres appears quite stringy and elastic, the tracheæ and tougher tissues resisting decay adhering to the cell. Later nothing remains but a black, flat scale on the lower side near the bottom of the cell. If the disease does not assume the acute form before the pupa stage the brood is

capped over, but the cell cap, commonly of a darker color than that covering a healthy brood, settles, leaving the cover concave instead of flat or convex, and shortly small holes appear, as if inquiry had been instituted to learn the condition of the occupant, or to liberate the gases and odor and facilitate evaporation. Torn and ragged cell caps are frequent, and some cells may be empty and cleansed; and in the midst of ragged and sunken caps a live bee may occasionally emerge.

The means by which these deadly agents are commonly introduced into the hive and into the bodies of their victims has not been certainly determined. Prof. Frank R. Cheshire, F. L. S., F. R. M. S., to whom we are indebted for the classification of this species of *Bacillus*, and also for much that is valuable concerning its life history and pathogenic character, speaking of the means of propagating this disease, says (see Bees and Bee-Keeping, vol. 2, pp. 157, 158, London, 1888):

"My strong opinion is, that commonly neither honey nor pollen carry the disease, but that the feet and antennæ of the bees usually do." "It is also extremely likely that spores are carried in the air and taken in by the indraft set up by the fanners. There will be no difficulty in this supposition when it is remembered that the organisms are so minute that a cubic inch of material would form a quadruple line of them from London to New York."

My own experience and observation is in agreement with this last proposition, as witness the following paragraph from my report of last year (see Report of U. S. Entomologist, 1886, p. 587):

"That the contagion may sometimes be borne from hive to hive by the wind appears to be true, as it was observed in one of the apiaries which I treated for this disease during the past summer that of a large number of diseased colonies in the apiary, with the exception of two colonies all were located to the northeast of the colony in which the disease first appeared. The prevailing wind had been from the southwest."

Mr. Cheshire says further, page as above: "The bee-keeper is unfortunately almost compelled to become himself a probable cause of infection. His hands, made adhesive by propolis, carry the spores or bacilli, and so may transfer them, even hours later, to healthy hives. The clothes should be kept as far as practicable from contact with suffering colonies, and the hands after manipulating them should be disinfected by washing with a weak solution of mercuric chloride (corrosive sublimate), one-eighth of an ounce in 1 gallon of water being quite strong enough."

The concluding paragraph under this heading in my report for 1886 is as follows:

"That the disease germs may be carried upon the clothing and hands appears probable, from the fact that in one neighborhood this disease appeared in only two apiaries, the owners of which had spent some time working among diseased colonies at some distance from home, while other apiarists in that locality who had kept away from the contagion had no trouble from foul-brood."

It has been the common belief that honey is the medium through which the disease is most frequently introduced from both near at hand and remote sources of infection. That undue importance has been attached to honey as the common source of infection appears certain, for I have proved by repeated trials that if frames containing combs of capped honey, and having no cells containing pollen, be removed from infected hives and thoroughly sprayed or immersed, using an acid and alkaline solution of suitable strength to destroy the germs exposed to its action, the honey in such combs did not communicate disease when placed in healthy colonies and consumed by the bees as food for both summer and winter uses. I have found it altogether practicable to feed honey which had been extracted from infested combs without boiling, always adding, however, as a precaution, a disinfectant suitable to destroy any infection possibly lurking in such food.

In speaking of honey as a means of carrying this contagion, Mr. Cheshire says: "I have searched most carefully in honey in contiguity with cells holding dead larvæ; have examined samples from stocks dying out with rottenness; inspected extracted honey from terribly diseased colonies, and yet in no instance have I found an active bacillus, and never have been able to be sure of discovering one in the spore condition, although it must be admitted that the problem has its microscopic difficulties, because the stains used to make the bacilli apparent attach themselves very strongly to all pollen grains and parts thereof, and somewhat interfere with examination. I have now discovered that it is impossible for bacilli to multiply in honey, because they can not grow in any fluid having an acid reaction."

As to pollen being the medium by which this contagion is commonly introduced into the hive, not wishing to appear as speaking *ex cathedra*, I venture to say that further experiments in the line indicated in my report of last year leave little room to doubt the accuracy of the opinion then formed, namely, that pollen is the medium by which this contagion is most commonly introduced, and most rapidly

spread and persistently perpetuated. Continued observation showed that in those colonies where the largest quantity of pollen was being gathered the disease quickly assumed the malignant form, even when the quantity of brood was not greater than that being reared in other colonies where but little pollen was being gathered and in which the disease was far less virulent; and in this latter kind, where little pollen was being gathered, the contagion yielded most readily to treatment. But what seemed more to the point was, that from those colonies from which the combs containing pollen were removed and a suitable substitute furnished in the hive, thus avoiding the necessity for bringing supplies from the fields, the disorder was cured and the colony speedily regained their normal condition. The fact that queen larvæ seldom die from this contagion, taken in connection with what we know to be true concerning the character of their food, is significant, namely, that it is wholly composed of digested material, pollen grains being rarely found therein, and then as if present by accident and not by design, seems to justify the conclusion that the absence of pollen accounts for the absence of bacilli; while on the contrary the food of worker larvæ, secreted in excessive quantity and deposited in haste, occasional grains of pollen being dropped and no reason for their removal existing, the bacilli finding congenial cultures, multiply apace; and if perchance the larvæ escape infection, as is commonly the case until near the time of weaning, then live pollen being supplied, speedy and complete ruin results. Moreover, few if any bacilli are to be found in the chyle stomach of an adult queen at the head of a stricken colony, subsisted, as she must be, almost entirely upon secreted food produced by the worker bees; while in the chyle stomach of the worker, which partakes freely of pollen, they are present in quantity, and in fact line the whole intestinal tract.

The evidence presented in support of this pollen theory of the means of introducing and spreading this contagion is circumstantial, still it is component; and if it fails to reveal the true source of infection, the fact that the consumption of such live pollen as is obtained from the fields during the prevalence of this disease, or such old pollen as is stored in cells in which it may have molded or rotted and become a possible source of infection, aggravates the disease and makes it more persistent, and the fact that if the old pollen be removed from the hive and artificial pollen be substituted the malignant and persistent characteristics disappear, and that the contagion then readily yields to suitable treatment, is settled beyond question.

While it is true that queen bees have less to fear from infection in the larval stage, it is also true that queens reared in infested colonies are commonly worthless. Of twenty-five queens so reared in one apiary and successfully established at the head of as many colonies, not one survived the period of hibernation. In case the contagion does not assume the acute form in the larvæ it may localize and become chronic, and so, the bacillus of disease being as unnatural as disease itself, both worker and queen may live on for weeks and months, and the queen, with both life and death within her, transmitting the possibilities of both. Mr. Cheshire has counted as many as nine bacilli in a single egg, a discovery full of significance when striving to account for the spread of disease. It is but natural that this contagion, being a disease of the blood, should find congenial and luxuriant feeding-ground among the most delicate and highly organized glands and tubes of the ovaries.

We may reason thus: The bee-pap furnished to the queen larva, the protoplastic egg-food, copiously furnished to the queen during the breeding season, is continuous and passes from cell to cell. The germ cell of bacillus contributed to the organism of the queen in larval or in egg-food, borne along through the digestive and circulatory system, passes within the ovarian tubes and from thence into the nascent egg-cell, and once within the yolk is ready to contend for supremacy against the spermatozoid soon to be introduced. But the strife is unequal, and instead of the differentiating principle determining the form, function, and instinct of a new creature appointed to long life and service, the bacillus. finding the environment suited to multiplication, sterilizes the blood and riddles the tissues and viscera.

The remedy which I have found to be a specific—by the use of which I have cured hundreds of cases, many of which seemed hopelessy incurable, without failure and without a return of the contagion, except in the case of two colonies of black bees, where the disease reappeared in a form so mild that each colony was speedily cured, each one casting a swarm and making a fair amount of surplus honey—is prepared and applied substantially as directed in my last annual report.

In 3 pints of warm soft water dissolve 1 pint of dairy salt. Add 1 pint of water, boiling hot, in which has been dissolved four tablespoonsful of bicarbonate of soda. Dissolve one-quarter ounce of pure salicylic acid (the crystal) in 1 ounce of alcohol.

Add this to the salt and soda mixture, then raise the temperature near to the boiling point, and stir thoroughly while adding honey or sirup sufficient to make the mixture quite sweet, but not enough to perceptably thicken, and leave standing for two or three hours, when it is ready for use. An earthen vessel is best. I have tried other acids and alkalies in other forms, but the remedy prepared as directed and applied warm is that which I prefer.

Treatment.—Upon removing the cover from the hive thoroughly dampen the tops of the frames and as many bees as are exposed by blowing a copious spray of the mixture from a large atomizer. Beginning with the outside, lift a frame from the hive and throw a copious spray over the adhering bees on both sides of the comb, shake off part of the bees into the hive, and spray those remaining; then shake and brush these into the hive; then blow a copious spray of the warm mixture over and into the cells on both sides of the combs sufficient to perceptibly dampen both comb and frame. In like manner treat all the frames, seriatim, returning them to the hive in order. From combs containing very much pollen the honey should be extract d and the combs melted into wax. This extracted honey may be fed with safety, 2½ ounces of the remedy being added and well stirred into each quart of honey.

All the colonies in the apiary should be given a thorough spraying the first time the treatment is applied, but combs containing pollen need not be removed from healthy colonies. After the first thorough treatment the combs and bees should be thoroughly sprayed with the remedy at intervals of two or three days until cured. Three treatments after the first thorough application are commonly sufficient. First one frame being lifted from the hive and sprayed and the others simply set apart, so that the spray may be well directed over and copiously applied to both bees and combs. An essential feature in my method of treatment, which I failed to make duly significant and prominent in my last annual report, is that medicated honey or sugar sirup should be continuously fed to all infected colonies while they are convalescing, for not only must the contagion be driven from the organism of the adult bee and suitable food and tonic given to aid in repairing the ravages of disease, but a constant and even supply of the remedy serves as a preventive and cure for the larvæ.

The honey or sirup should be fed warm, and two ounces of the remedy should be well mixed in each quart of food, which may be given in feeders or by pouring over and into empty combs and placing these in the hive.

To prevent the bees from going abroad for supplies. make a thin paste of rye flour and bone flour, three parts of the former to one of the latter, adding the medicated honey or sirup. Spread this over a small area of old comb and honey in the hive, or feed in shallow pans or wooden butter dishes in the top of the hive or outside in the apiary, under shelter from rain. I prepare the bone flour by burning dry bones to a white ash. The softest and whitest pieces I grind to dust in a mortar and sift through a very fine sieve made of fine wire-strainer cloth. The coarser pieces of burned bone I put in open vessels with lumps of rock salt, which I keep half covered with sweetened water and sheltered from the rain, at all times accessible to the bees. The rapidity with which depleted colonies recuperate and become populous is surprising. I have tried supplying the saline, alkaline, and phosphate elements in bee food by using boracic acid, phosphoric acid, etc., but I find that the bees take kindly to the supplies prepared as I have directed, and the amount consumed shows their appreciation and need. Such supplies of food and drink should be kept at all times in the apiary, easy of access. I have not found disinfecting of the hives necessary further than to simply dampen the inside with a copious spray of the remedy, and sometimes no care was taken to do even this.

Starved Brood.

A disorder which has been quite common in several States during the past season is resultant from conditions prevalent during severe and protracted droughts, and long periods of extremely high temperature, such as has existed over large areas.

The disorder is significant and important, not so much on account of the actual numerical loss entailed upon colonies affected, which in my own case and in many cases reported to me have been severe, as in furnishing proof of failure on the part of those food elements indispensable during the breeding season to meet the large demand for larval food and essential in maintaining the health and vigor of the bees while the digestive and secretory organs are being taxed to the limit of their capacity. This failure of natural resources results in low vitality, susceptibility and predisposition to disease, and inability to successfully perform the function of hibernation. With some exceptions, due to local advantages, throughout the States stricken by the drought of the past summer the bees have entered upon the period of

hibernation under conditions more or less unfavorable in proportion as they have suffered in greater or less degree from the effects of the all-consuming drought and heat.

The symptoms of starved brood are distinctively characteristic. Upon opening the hive a slightly offensive odor may be noticed if the colony has been suffering for some time. If the comb-frame be lifted from the hive and the bees shaken off few if any eggs can be found. Of such brood as is sealed the cappings appear to be thin and flat and slightly sunken, and commonly of darker color than is usual in prosperous colonies. Upon opening the cells they are found to contain dead pupæ in various stages of development, always inferior in size, and the food supply exhausted. In the midst of sealed brood patches of uncapped larvæ appear, and sometimes a patch of 5 or 6 inches square, and sometimes there seems to have been no effort made towards sealing half the grown larvæ in the hive, although the time for such sealing may be far overdue. The membranes of such larvæ do not present the plump pearly-white appearance common to well-fed larvæ. On the contrary, the membranes are more or less shrunken and wrinkled, and not unfrequently, when the larvæ have reached the advanced pupa stage, the compound eyes begin to color and the cells are partially capped and then abandoned, and the appearance is that commonly designated by the term "bald-headed bees." Sometimes a few of these bees, dwarfed in size, emerge from the cells and engage in the labors of the hive with what vigor and for such term as their limited development will permit. In a number of tests made during the past season the progeny of the same queen, reared under directly opposite conditions of larval growth, so varied in size as not to be recognizable as offspring of the same progenitors. The reason for this variation was not far to seek. The changed conditions of the colony during the time when the different generations were being reared determined the modification in development. The remedy I used and prescribed for others was preventive rather than curative. Starved brood means starved bees. If the cause be removed the effect speedily disappears. All that needs to be done is to supply them with a substitute for those resources essential to their own health and vigor and indispensable in brood-rearing, in search of which they are rapidly and vainly wearing out their vitality.

The recipe for preparing the remedy is as follows:

To 10 pounds of sugar add half a pint of dairy salt, 2 table-spoonsful bicarbonate of soda, 2 table-spoonsful rye flour, 2 table-spoonsful very finely powdered bone ash, and 1 table-spoonful cream tartar. Mix thoroughly, then add 2 quarts hot water, and stir until thoroughly dissolved, then boil for two or three minutes only. To one-half pint fresh milk add 3 fresh eggs thoroughly beaten, and when the sirup is cool enough to feed add the eggs and milk, and when thoroughly stirred feed warm. Feed in the hive as one would feed honey or sirup.

I used this same food for preventing spring dwindling and for building up colonies to full strength and efficiency, so that all colonies may be ready for work at the very beginning of the season when surplus honey may naturally be expected. This food fed in the hive keeps all the bees at home to aid in performing the functions of brood-rearing and in keeping up the temperature of the hive instead of spending their little remaining strength in battling against the cold, damp winds while searching for the food elements needed to repair the waste and drain upon their vitality while hibernating, and indispensable in brood-rearing. This food is not intended for use until after the bees have had a good flight in spring and almost any grade of honey or sugar may be used. This special food is a potent stimulant and tonic to the adult bees, giving tone and vigor to the organism, and furnishes the elements essential in brood-rearing in the place and in the manner suited to the convenience and tastes of the bees. No greater quantity should be fed than is required for the current needs of the colony.

THE CONTROL OF REPRODUCTION.

In order that the laws of heredity and the active principles of selection may be practically and persistently applied in the breeding of bees, I have in obedience to your instructions continued my experiments, striving to discover a simple and practical method for securing control of the natural process of reproduction.

I devised and constructed a fixture, which I call a fertilizing cage, 22 feet square and 26 feet high. Selecting a level plot of ground I set 4 rows of posts, 4 posts in each row, forming a quadrangle. These posts are 4 inches square and 30 feet in length, set into the ground 4 feet and exactly 7 feet apart. Four rows of girders, 2 by 4 inches by 22 feet 4 inches are halved in two and bolted to the inside of these posts, the first row 5 feet from the ground, then three rows at intervals of seven feet until the top is reached. The upper 3 lines of girders are continued from each side of each

inside post, forming a brace on each side of each post at intervals of 7 feet, and forming the bearings for the wire-covered frames which cover the top of the cage. The space from the ground to the first girder, 5 feet, is covered with matched lumber nailed to the outside of the posts, leaving a smooth surface on both sides. The upper 21 feet on the sides and the top of the cage is inclosed by wire-covered frames 7 feet square, bolted to the girders on the sides and securely fastened with screws to the frame-work at the top. The height of the cage is thus adjustable at 26 feet, 19 feet, or 12 feet from the ground by simply lowering the screen frames forming the top, and the upper row (or two upper rows as the case may be) forming the sides of the inclosure, the purpose being not only to determine whether queens or drones would mate in this cage at full size, but also how small an inclosure would be sufficiently large to give suitable freedom and range of flight.

These wire-covered frames are framed like a two-light window-sash, with a mullion in the center, on which the two breadths of wire-cloth meet. Strips of wood secure the edges of the cloth and cover all joints at the sides of the frames. With the lower board of the siding settled into the ground and earth filled against the inside and the door tight-fitting the cage is bee-tight. I used drab-colored wire cloth, which obstructs the light but very slightly. A shelf is fitted against the four sides of the cage on the inside 1 foot from the ground and alighting boards directly opposite on the outside. Upon this shelf the hives are placed. Each hive has an exit cut in either end and an exit is cut through the wall of the cage registering with the outer exit of each hive, over which, on the outside of the wall, a piece of queen-excluding zinc is nailed. These hives are painted strikingly distinguishing colors, as red, white, blue, green, yellow, and black, and a space opposite each on the alighting boards and a corresponding space on the outside of the wall of the cage are painted in corresponding colors. The colors are repeated in the order named, which separates the hives of the same color a sufficient distance to prevent confusion, and bees and queens readily distinguish their own hive by means of color as readily as by location. If the inner exit be left closed for a day or two after a colony is placed in a cage the worker bees readily learn to enter their own hive upon returning from the fields. I found that the queens had no difficulty on returning to their own hives after taking flight in the cage. To test that fact I frequently opened a number of hives in succession and placing the queens upon the palm of my hand tossed them high in the air, when they would take wing and fly away. Upon re-opening the hives a few minutes later they would be found upon the combs. The queens and drones appeared to fly and disport themselves with as much freedom and regularity in the cage as they did in the apiary outside. The virgin queens were introduced from the nursery by various methods. Some were hatched in colonies in the cage from cells matured in strong queenless colonies and some from cells built under the swarming impulse, which this season could be produced by artificial means only. Mature drones were selected from the hives in the apiary and also from those returning from their excursions and liberated in the cage, and sealed drone-brood was removed from hives in the apiary and hatched in strong colonies built up in large hives in the cage, and these drones all flew with freedom and regularity. A few times I observed a queen embrace a drone and fly all about the cage with entire freedom. and then, the embrace being broken, each flew away in different directions, the queens returning to their hives and the drones at once rejoined their fellows in the upper part of the cage. It is needless to add that in such cases no accouplement had taken place.

The results realized from this line of experimental work have been so meager and the circumstances attending the experiments so exceptionally unfavorable that it is not easy to form an estimate of their value or determine their significance. Of the many scores of trials made but six were successful; but six queens were fecundated in the fertilizing cage. However, as the improvement of the bee to the highest attainable excellence outranks all other considerations in practical importance and scientific interest, the methods and results of any intelligently-conducted experiments having this end in view are well worth placing on record. Besides future trials may receive direction from a multitude of failures and the trying experience of the past season is not without compensating features, for even the little gains we make in positive knowledge, although apparently trifling in themselves, have often significant meaning and broad bearing on questions of great value.

My experience and observation lead me to believe that the main reason why this experiment was not satisfactorily successful was because of the protracted drought and high temperature which lasted through the entire breeding season, the like of which has not before been known in this region. From May, 1886, until December, 1887, drought prevailed, broken only at long intervals by light showers. The succession of two summers of excessive heat and unbroken drought insured disaster to the present season cumulative in kind and intensified in degree. Continuous

feeding has been required to keep up breeding and to prevent starvation. Whenever feeding was suspended for two or three days, throughout nearly the entire season, oviposition would cease and the bees ate their eggs, and it has required persistent trials and careful management to rear drones and keep them alive. It has been difficult to get three or four queen cells matured in colonies such as in ordinary seasons would rear from twenty-five to forty, and of those permitted to remain outside in the apiary and seek a mate at will two of every three failed of fecundation. During the entire season a large majority of the larval queens, being insufficiently fed, died in the cell, and when for days and weeks together the temperature ranged from 110° to 120° F. in the sun during several hours each day the pap-food would ferment and turn a dark amber color and dry up to the consistency of thick glue at the bottom of the cells with the dead pupæ. When the temperature ranged from 100° to 110° F. in the sun the average temperature in the hive was from 5° to 2° higher until 112° was reached. Then, when the range in the sun was from 115° to 125° the temperature did not go above 112° in the hive. The fanners were able to prevent the temperature rising above 112° in hives standing in the sun with a shade-board above the hive-cover. The worker larvæ seem to be able to endure a higher temperature than queen larvæ. This season, as a rule, the drones were much smaller than drones from the same ancestors in the summers of 1885 and 1886, and there was a great inequality in the size of drones and queens of the same parentage and reared at the same time in the same hive, and a very unusual proportion of the queens were deformed and unable to fly.

Continued observation and experiment furnish corroborative evidence of the correctness of the theory advanced in my last annual report, namely, that drone bees differ in degrees of procreativeness, properly classified as the impotent, the conditionally potent, and the potent; and that it is the prerogative of the worker bees to determine the degree of development and dominate the function of the drones as they determine the kind and degree of development of instinct and organism and dominate the functions of the queen. The volition of the queen determines the sex of every one of her descendants; but the life of every individual as well as the modifications in organism and instinct depends upon and receives its direction from the worker bees, whose unerring prescience forbids the rearing or maintaining of individuals for whose services there exists no present or prospective demand. It is only when this keen apprehension of the present and prospective conditions of environment indicates a necessity for rearing and maturing potent or potentially potent individuals that such are reared and matured and furnished for the functions they are to perform. Under circumstances unfavorable in the extreme a condition of seeming prosperity may be artificially produced, and drones numerically plentiful may be reared and preserved alive. It has taxed my skill and patience to the last degree during the past season to do this. I resorted to every strategem I could devise to secure a supply of mature drones, but in most cases the workers were either unable or unwilling to supply the drone larvæ with food suitable in kind and quantity, for a large proportion of the drones were dwarfed. Dissection showed the sex organs of this sort to be inferior in size, dry, and empty. Not one drone in one hundred of those which were fully developed, when held by the legs or wings or when pressed upon the thorax, were able to perform the expulsion act, and the sex organs of such, with rare exception, contained nothing but a little clear, thin mucous. I have during the past season at various times examined the contents of the sex organs from scores of drones well developed and structurally perfect of the class which I believe to be potentially potent, in which I have not been able to discover active spermatozoa, nor was the mucous secretion present of that color and consistency which I believe to be the product of special feeding and indispensable to sexual desire, and for liberating and floating the spermatozoa into the spermatheca.

Without wishing to appear dogmatic, after another season exceptionally favorable for such observation and experience as has furnished more complete data and corroborative evidence, I venture to reassert my belief as set forth substantially in my last annual report, that the preparation for and exercise of the reproductive faculty in drone bees, as well as in queens, depends upon and is determined by the workers. As with the queen so with the drone, desire and capacity wait upon the will and resources of the workers.

As the queen must be bountifully supplied with egg-food before the egg-cells begin to germinate and mature in the ovaries, so I believe the drone must be well supplied with that special food suited and intended to produce the desire and capacity for performing the act of copulation, the giving and withholding of which is instinctively determined by the worker bees as the present and prospective condition demands. Throughout the past season of extreme heat and protracted drought there was almost total failure of all natural resources, and all the influences of nature to

which bees are subject warned them that there was no actual necessity for feeding and maturing drones, and that the abundance and prosperity with which I had supplied them were artificial and deceptive. In the impotency of the drones, almost universally prevalent, I find the reason for the almost total failure of this experiment. The fact that both drones and queens flew with freedom and regularity in the cage, and the fact that in a few cases queens were successfully mated in the cage when but few were successfully mated outside leads me to believe that under favorable conditions satisfactory success may be expected. Experiments in breeding bees during the prevalence of such climatic conditions as those of the past season are attended with hindrances which I have not been able to overcome. My experience and observation have suggested some changes in the size, shape, and manner of constructing the cage which I believe would be an improvement. If, under favorable circumstances, the control of the process of reproduction can be secured by the use of a device permanent in kind and of moderate cost then every queen breeder and progressive bee-keeper may apply the laws of heredity and the principles of selection to the breeding of bees with assurance of realizing results alike in kind and degree to those which have by the persistent application of the same laws and principles been realized in breeding all kinds of domestic animals.

I have, by establishing mating stations in localities remote from other bees, secured the mating of queens and drones selected on account of their excellent paternity and perfect development. I controlled the flight of the different varieties by the use of queen-excluding zinc. By crossing selected individuals of different varieties, and by mating selected bees of the same variety avoided in breeding, I have laid the foundation for some ancestral stock of superior excellence. This kind of work requires much patience and persistence during such a season as that just ended. I have begun many other experiments, many of which failed, and others, lacking in completion, require no mention here.

EXPLANATION TO PLATES TO REPORT OF ENTOMOLOGIST.

Where figures are enlarged the natural sizes are indicated in hair-lines at side, unless already indicated in some other way on the plate.

EXPLANATION TO PLATE I.

THE CHINCH BUG.

(Original.)

FIG. 1.—Stalk of wheat showing Chinch Bugs at work—natural size.

FIG. 2.—The eggs, showing slight variation in color, and the terminal caps—greatly enlarged.

FIG. 3.—Larva of second age—greatly enlarged.

FIG. 4.—Larva of third age—greatly enlarged.

FIG. 5.—Pupa—greatly enlarged.

FIG. 6.—Adult insect, normal type—greatly enlarged.

FIG. 7.—Adult insect, ordinary short-winged form (Fitch's var. *apterus*)—greatly enlarged.

FIG. 8.—Adult insect, short-winged form from the sea-shore—greatly enlarged.

EXPLANATION TO PLATE II.

THE CODLING MOTH AND ITS PARASITES.

(Original, except fig. 5.)

FIG. 1.—Nearly full-grown larva, from side—enlarged.

FIG. 2.—Chrysalis from side—slightly enlarged.

FIG. 3.—Adult, from above, with expanded wings—slightly enlarged.

FIG. 4.—Adult, from above, wings closed—slightly enlarged.

FIG. 5.—Apple cut open, to show work of larva which has become full grown and issued: *a*, full-grown larva; *b*, moth at rest; *c*, the less common channel of exit through cheek of apple; *d*, the point where the egg was laid, showing original channel of entrance, afterwards enlarged for the purpose of pushing out excrement—all natural size (redrawn from Riley).

FIG. 6.—Apple oviposited in by second brood of moths, cut open, showing appearance before larva has reached half growth—natural size.

FIG. 7.—*Pimpla annulipes*, female—enlarged.

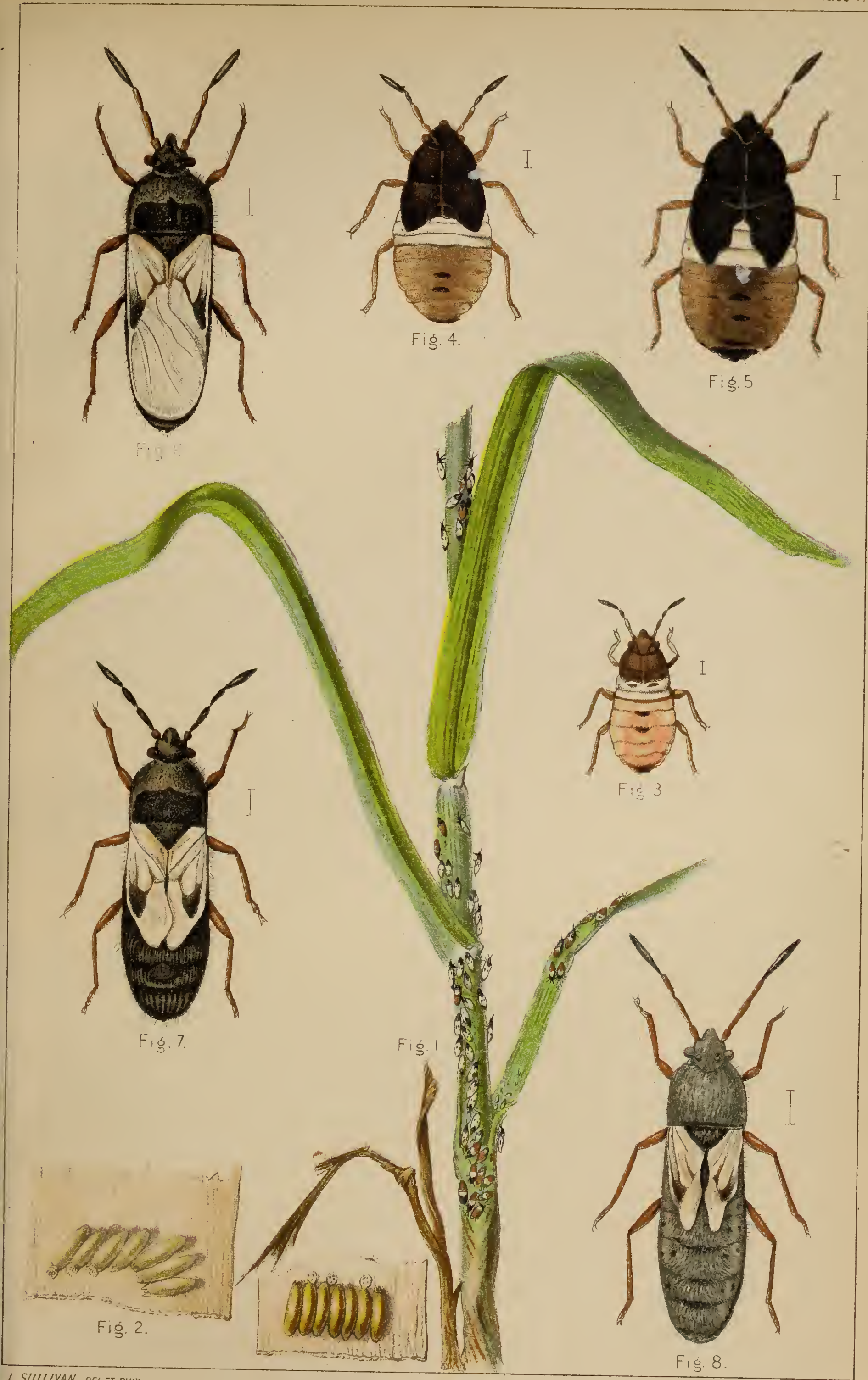
FIG. 8.—*Macrocentrus delicatus*, female—enlarged.

EXPLANATION TO PLATE III.

FIG. 1.—Immature stages of the Chinch Bug: *a*, *b*, eggs; *c*, newly-hatched larva—both greatly enlarged; *d*, its tarsus—still more enlarged; *e*, larva after first molt; *f*, same after second molt; *g*, pupa—all greatly enlarged; *h*, enlarged leg of adult; *j*, tarsus of same—still more enlarged; *i*, proboscis or beak—greatly enlarged (after Riley).

FIG. 2.—Adult Chinch Bug, short-winged variety—enlarged (after Riley).

FIG. 3.—Adult Chinch Bug, normal form—enlarged (after Riley).



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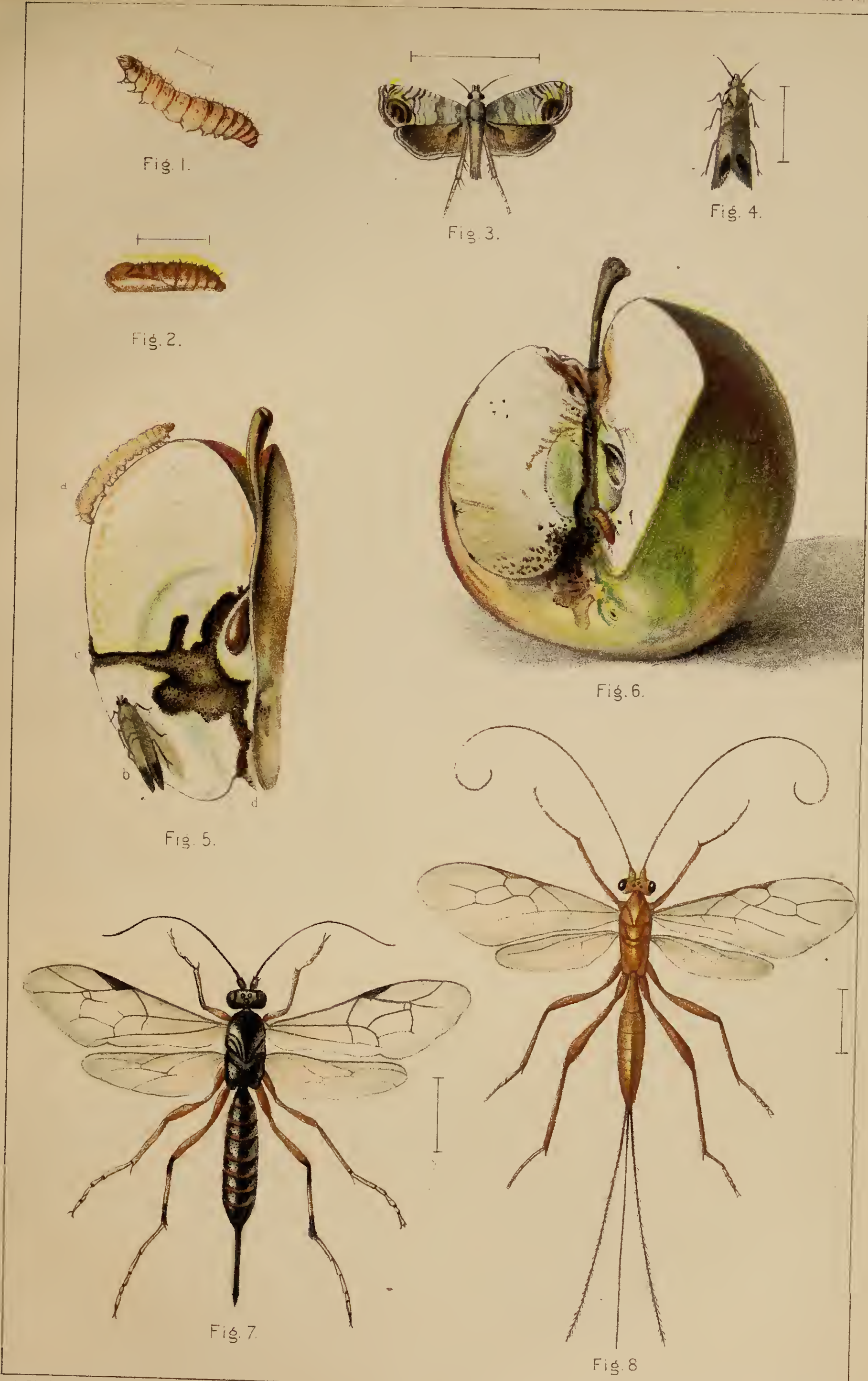
THE CHINCH BUG.



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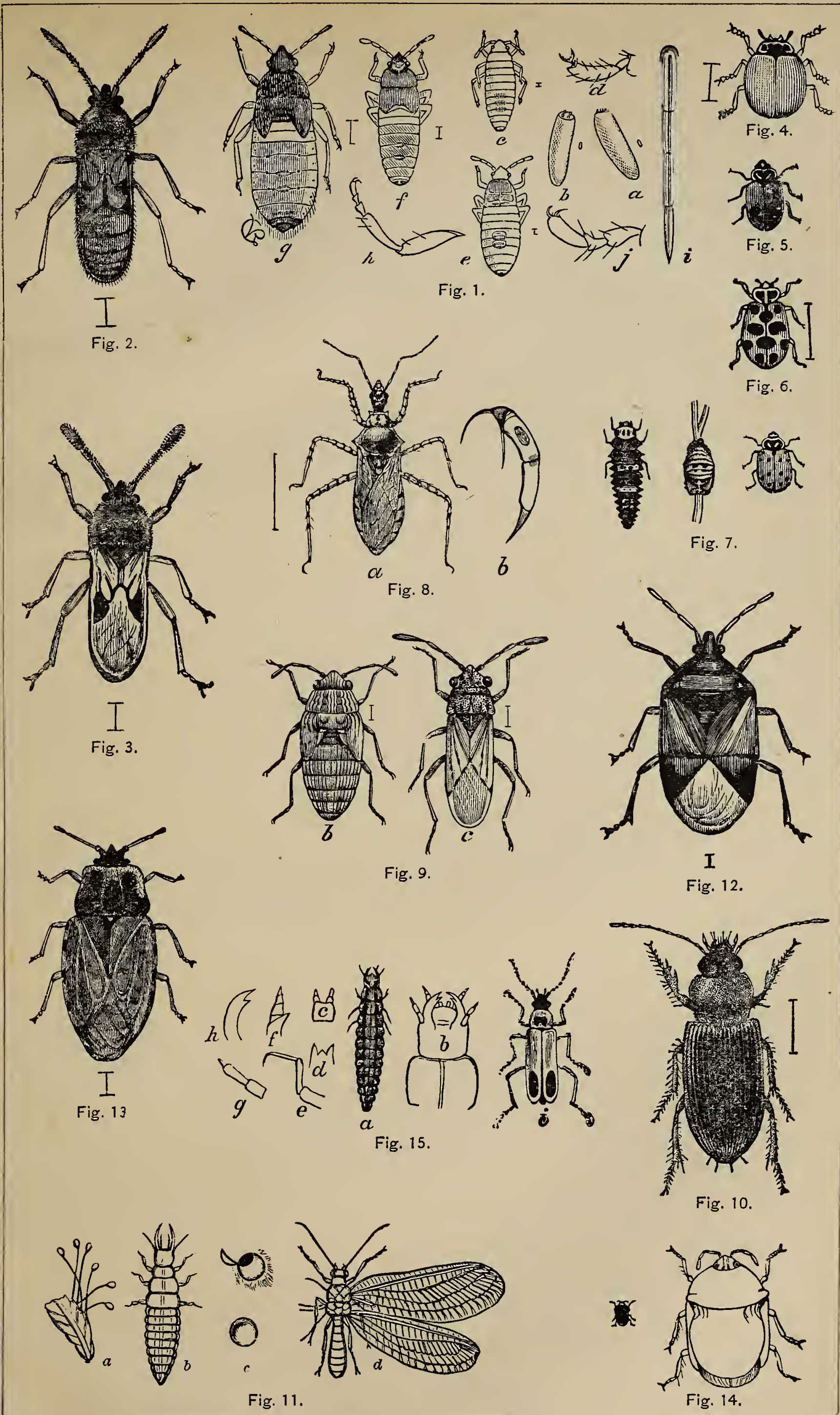
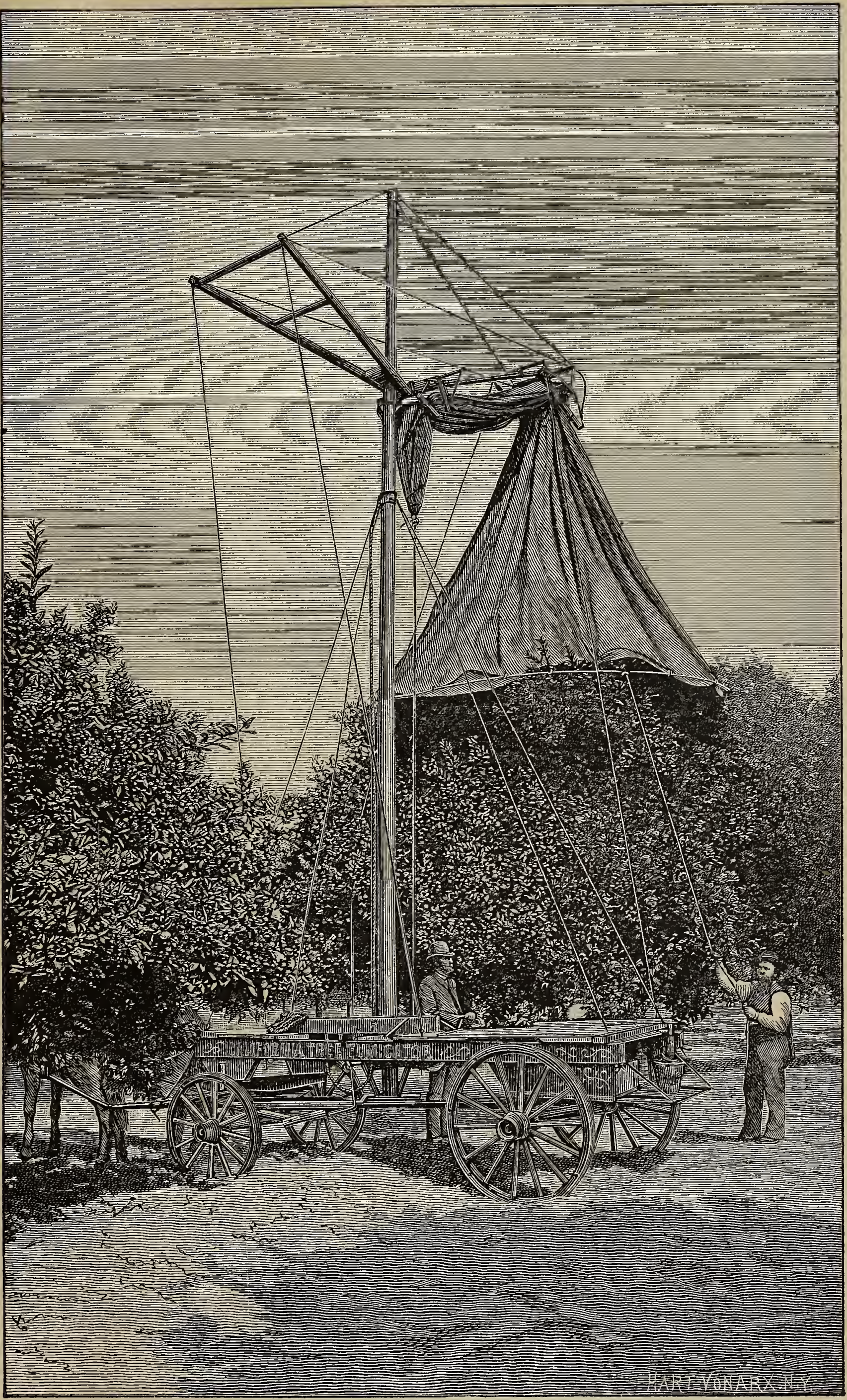
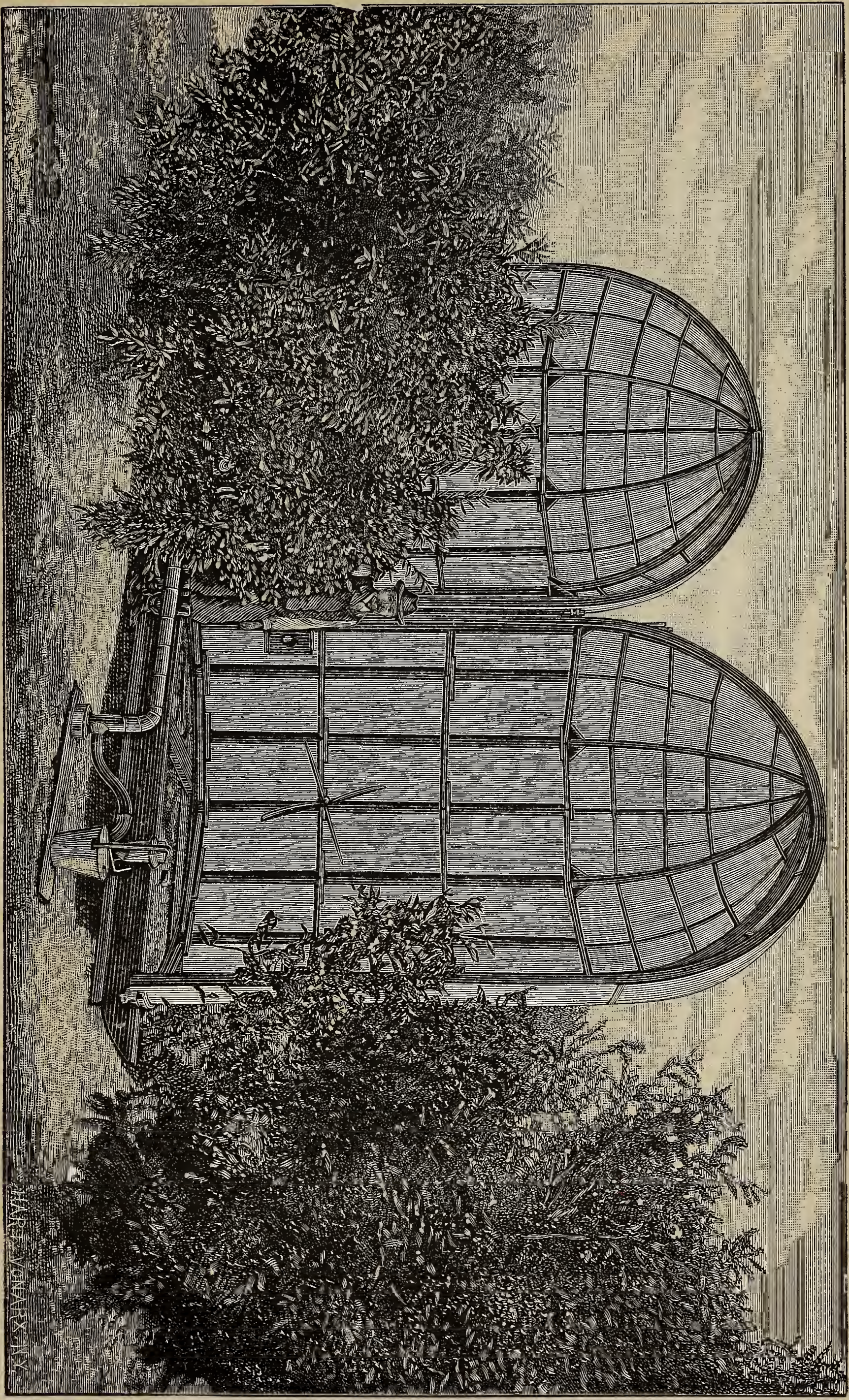
THE CODLING MOTH AND ITS PARASITES.



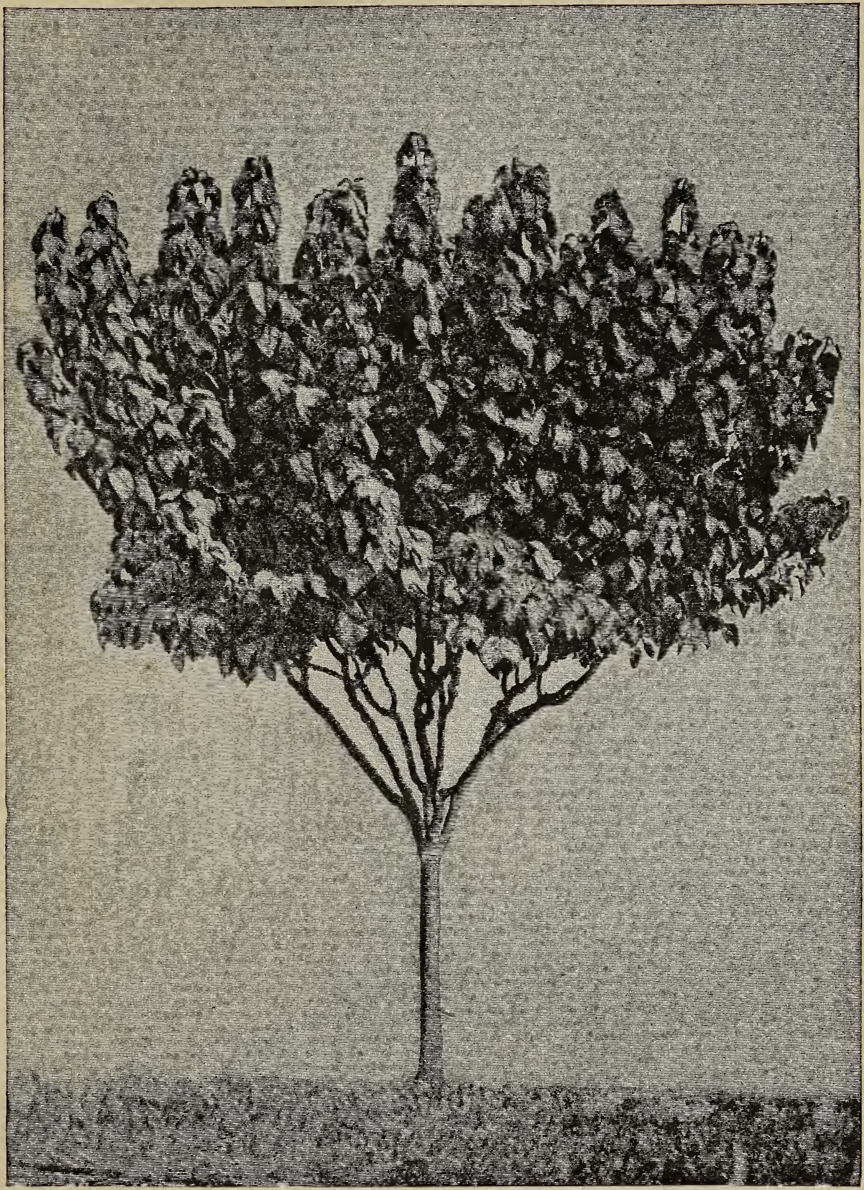
MISCELLANEOUS INSECTS.



THE WOLFSKILL FUMIGATOR.



THE CULVER FUMIGATOR.



CATTANEO "PRIMITIVE" MULBERRY TREE EIGHT YEARS FROM THE SEED.

CATTANEO "PRIMITIVE" MULBERRY TREE, SHOWING METHODS OF PRUNING.

FIG. 4.—*Cycloneda sanguinea*, an enemy of the Chinch Bug—enlarged (after Riley).

FIG. 5.—*Hippodamia glacialis*, an enemy of the Chinch Bug—natural size.

FIG. 6.—*Hippodamia maculata*, an enemy of the Chinch Bug—enlarged.

FIG. 7.—*Hippodamia convergens*, an enemy of the Chinch Bug: *a*, larva; *b*, pupa; *c*, adult—all natural size (after Riley).

FIG. 8.—*Milyas cinctus*, an enemy of the Chinch Bug: *a*, adult bug—enlarged; *b*, its beak—still more enlarged (after Riley).

FIG. 9.—*Nysius angustatus*, frequently mistaken for the Chinch Bug: *b*, pupa; *c*, mature bug—enlarged (after Riley).

FIG. 10.—*Agonoderus pallipes*, an enemy of the Chinch Bug—enlarged (after Riley).

FIG. 11.—*Chrysopa plorabunda*, an enemy of the Chinch Bug: *a*, eggs; *b*, larva; *c*, cocoon; *d*, adult—all enlarged.

FIG. 12.—*Triphleps insidiosus*, an enemy of the Chinch Bug, frequently mistaken for it—enlarged.

FIG. 13.—*Piesma cinerea*, mistaken for Chinch Bug—enlarged (after Riley).

FIG. 14.—*Corimelæna pulicaria*, mistaken for Chinch Bug—enlarged (after Riley).

FIG. 15.—*Chauliognathus pennsylvanicus*, an enemy of the Codling Moth: *a*, larva, full grown—natural size; *b*, *c*, *d*, *e*, *f*, *g*, *h*, head parts—enlarged; *i*, adult beetle—natural size (after Riley).

EXPLANATION TO PLATE IV.

(Engraved from a photograph.)

The Titus fumigator—invented in California for the gas treatment of trees infested with Scale-insects.

EXPLANATION TO PLATE V.

(Engraved from a photograph.)

The Wolfskill fumigator—another device for the same purpose.

EXPLANATION TO PLATE VI.

(Engraved from a photograph.)

The Culver fumigator—another device for the same purpose.

EXPLANATION TO PLATE VII.

(Engraved from a photograph.)

Cattaneo "Primitive" Mulberry tree, eight years from the seed.

EXPLANATION TO PLATE VIII.

(Engraved from a photograph.)

Cattaneo "Primitive" Mulberry tree, showing methods of pruning.

GENERAL INDEX.

PLANT INDEX.

V